SUGARCANE RESEARCH

Annual Progress Report

1993

Louisiana State University
Agricultural Center
Louisiana Agricultural Experiment Station

SUGARCANE RESEARCH

ANNUAL PROGRESS REPORT

1993

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Louisiana Agricultural Experiment Station, K. W. TIPTON, Director

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FOREWORD

Research on sugarcane in the Louisiana Agricultural Experiment Station is an integral part of the LSU Agricultural Center's research-extension effort to provide the knowledge and technology base for efficient production and processing of sugarcane. Sugarcane research projects are led by scientists in the Sugar Station/Audubon Sugar Institute, and the departments of Agricultural Economics and Agribusiness, Agronomy, Biological and Agricultural Engineering, Entomology, and Plant Pathology and Crop Physiology.

Members of the Louisiana Agricultural Experiment Station maintain close working relations with colleagues in respective departments of the College of Agriculture and other colleges of the LSU Baton Rouge campus, the Louisiana Cooperative Extension Service, the Agricultural Research Service and Soil Conservation Service of the USDA, the American Sugar Cane League, and the Louisiana Department of Agriculture and Forestry.

A major portion of the resources for production and processing research are linked to the St. Gabriel Station and Sugar Station/Audubon Sugar Institute respectively. The Iberia Research Station helped to accomplish specific sugarcane research objectives in 1993.

Important parts of the 1993 research effort were conducted on cooperating farms and in cooperating factories throughout the industry. The dwindling of the farm labor supply has been making the evaluation of location effects and location interaction effects increasingly difficult. However, these evaluations are very important and must be continued. **The cooperation of individual farms and sugarcane factories in conducting research projects and financial support of the American Sugar Cane League is gratefully acknowledged.**

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Louisiana Agricultural Experiment Station
Louisiana State University Agricultural Center
Baton Rouge, Louisiana 70803

and

United States Department of Agriculture
Agricultural Research Service
Washington, D.C. 20250

and

American Sugarcane League of the U.S.A., Inc.
Thibodaux, Louisiana 70301

Notice of Release of Sugarcane Variety LCP 85-384

The Louisiana Agricultural Experiment Station of the Louisiana State University Agricultural Center, the Agriculture Research Service of the United States Department of Agriculture and the American Sugarcane League of the U.S.A., Inc., working cooperatively to improve sugarcane varieties, have jointly developed and hereby announce the release of a new variety, **LCP 85-384**, for commercial planting in the fall of 1993.

LCP 85-384 was selected from progeny of the cross CP 77-310 x CP 77-407. The variety produces very high populations of small diameter stalks with stalk weights less than CP 70-321. The stalks are light green to almost white and possess leaf sheaths with a high degree of pubescence and a necrotic margin that includes the auricle. Results from 82 replicated trials among 7 years and 17 test locations indicate LCP 85-384 yields superior sugar and cane yields, and stalk populations per area compared to CP 65-357, CP 70-321 and CP 74-383, particularly in the stubble crops. The recoverable sugar content of the variety is similar to CP 65-357 and has a milling factor of 1.024 and a cane fiber content of 12.48%. The variety is suited to mechanical harvesting, with harvesting characteristics similar to CP 70-321.

LCP 85-384 is susceptible to injury caused by the sugarcane borer, *Diatraea saccharalis* (F.)., is moderately resistant to smut (*Utilago scitaminea* Syd. & P. Syd.), resistant to the sugarcane mosaic virus and is susceptible to ratoon stunting disease (*Clavibacter xyli* subsp. *xyli*). Preliminary data suggest that the variety is tolerant to herbicides used in sugarcane production.

Seed cane will be distributed by the American Sugar Cane League in accordance with procedures to be announced to all sugarcane growers in Louisiana on or after July 7, 1993. Inquires concerning seed cane should be directed to the American Sugar Cane League, 206 E. Bayou Rd., Thibodaux, LA 70301. The Louisiana Agricultural Experiment Station and the United States Department of Agriculture do not have seed cane available for distribution.

Each agency will make such news releases as considered appropriate.

K.W. Tyton — 6/9/93
Director, Louisiana Agricultural Experiment Station — Date

C.E. Simmons — 6/24/93
Administrator, Agricultural Research Service — Date

Graham B. Bright — 7/6/93
Chairman of the Board
American Sugar Cane League of the U.S.A., Inc. — Date

AN OVERVIEW OF THE LOUISIANA "L" SUGARCANE VARIETY DEVELOPMENT PROGRAM

F. A. Martin
Sugar Station/Audubon Sugar Institute

The most significant event for the Louisiana Sugarcane Variety Development Program in 1993 was the release of LCP 85-384 for commercial production. We trust that this variety will contribute to the well being of the Louisiana sugarcane industry. There are three points associated with the release of the variety that merit comment. The first point is that release of a variety is the highest achievement in the discipline of plant breeding. LCP 85-384 is the third variety release in four years that was selected by LAES sugarcane breeders. The second point is that the LAES team and the USDA team cooperate to achieve more than either can achieve independently. The crosses that produced this variety and the two other recent releases, LCP 82-89 and LHo 83-153, were produced by USDA breeders. The final point is that achievements in plant breeding are built on foundations laid by those who came before us. The parents of these varieties were commercial CP varieties and varieties that were developed through the USDA Basic breeding program. Likewise, today's achievements are the foundation for tomorrow's progress. Progress in the "L" Sugarcane Breeding and Variety Development Program would not be possible without the support of the Director of the Louisiana Agricultural Experiment Station and the financial support of the American Sugar Cane League.

Although each member of the LAES Sugarcane Variety Development Team has a specific area of responsibility, each team member also has a general understanding of the entire program and often is called upon to assist in other areas of the program. Current team members (Table 1) contribute expertise in the areas of agronomy, breeding, genetics, statistics, entomology, pathology, weed science and physiology.

Table 1. Members of the LAES Sugarcane Breeding and Variety Development Team.

Team Member	Budgetary Unit	Responsibility
F. A. Martin	Agronomy/Sugar Station/ASI	Program Leader
K. B. Bischoff	Agronomy	Selection
S. B. Milligan	Agronomy	Methodology/Genetics
H. P. Schexnayder, Jr.	St. Gabriel Station	Photoperiod & Crossing
P. H. Rodriguez	Agronomy	Variety Testing
G. L. Hawkins	Sugar Station/ASI	Sucrose Lab
H. P. Schexnayder	St. Gabriel Station	Farm Manager
H. P. Viator	Iberia Station	Variety Testing
K. L. Quebedeaux	Iberia Station	Variety Testing
T. E. Reagan	Entomology	Insect Resistance
J. W. Hoy	Plant Pathology & Crop Physiology	Disease Resistance Testing
J. L. Griffin	Plant Pathology & Crop Physiology	Herbicide Tolerance

The LAES sugarcane breeding team and the USDA sugarcane breeding team work independently yet cooperatively to produce "L" and "CP" varieties respectively. The best varieties from the two programs are brought together for evaluation at the "outfield test locations". Outfield testing is conducted by personnel of the Louisiana Agricultural Experiment Station, the United States Department of Agriculture, and the American Sugar Cane League in accordance to the provisions of the "Three-way agreement of 1978". After 12 years of testing, those varieties that show promise are released for commercial production.

In the 1990 Sugarcane Annual Report, I briefly reviewed points of emphasis for the L program. We are continuing to emphasize these points. The distribution of L clones through stages of testing in 1993 is presented in Table 2. As compared with L varieties of the 1960 through 1980 series, more L varieties are being advanced further into outfield testing than before.

Table 2. Number of "L" clones by Series at most advanced stage of testing for the series in 1993.

Series	Stage of Testing	Year from seedling	Number of clones
L 1985	Release	13	1
L 1986	Outfield - Second Stubble	12	1
L 1987	Outfield - First Stubble	11	1
L 1988	Outfield - Plant Cane	10	2
L 1989	Outfield - Planted in outfield	9	1
L 1990	Outfield - Introduced	8	2
L 1991	Outfield - Introduced	7	13
L 1992	Nursery - Plant Cane	6	34
L 1993	Assignment	5	42

1993 PHOTOPERIOD AND CROSSING IN THE LOUISIANA "L" SUGARCANE VARIETY DEVELOPMENT PROGRAM

H.P. Schexnayder, Jr., S. B. Milligan, and F. A. Martin
St. Gabriel Research Station, Agronomy Department, and Sugar Station

The first step to success in the Louisiana "L" Sugarcane Variety Development Program begins with the production of viable "true" seed from the crossing stage of the program. Although sugarcane does not flower under ambient Louisiana conditions, it is induced to flower with photoperiodic adjustment. The response to photoperiod induction is quite repeatable and is used to induce and synchronize the flowering of desirable genotypes.

Natural lighting and dark chambers (photoperiod bays) were used to impose photoperiod treatments. To prevent overwhelming crossing facilities, two flowering peaks separated by two weeks were planned (Table 1). Clonal flowering and pollen production data were used to place clones on specific bays and carts. Specifically, the Days from the start of photoperiod treatment To the appearance of the First Flower (DTFF) within a treatment were used. The range of estimated DTFF is usually limited to 10d per cart. Easier to induce varieties on a cart, falling outside the 10d range, may have been removed prior to the start date and reinstalled later to tighten the predicted flowering range within the 10d span. More difficult to flower clones or those clones with no flowering history are generally placed within the late peak and the hardest to induce flowering treatments (bays 5 & 6). Clones that we plan to use as males are placed in center bays 3 and 4 to minimize heating cost. Easier to flower clones are more often placed in bays 1 through 3 with a few cans of these varieties in bays 4 through 6. Within a bay, the hardest to induce clones are placed on cart C because this is this first cart that can be rolled into the bay and hence photo-treatments can be started on varieties on this cart without starting treatments on varieties on carts B and A.

During the month of June, all varieties initially were exposed to a 12.5h photoperiod treatment which began when the photoperiod bays were opened 12.5h before natural sunset (table 1). The minimum number of constant 12.5 hour treatment days given before beginning decline treatment was increased to 30 in 1993. During July the reduction of day length by 1 min d^{-1} or ½ min d^{-1} until was begun. All photoperiod treatments were discontinued on September 10, 1993.

Three hundred twenty-four cans on carts in bays 1 through 6 were subjected to photoperiod treatments. Eighty-six of the varieties that flowered (283 cans) were used in crossing (Table 2). Experimental varieties that had undergone treatment but were dropped from the testing program (41 cans) were not used in crossing.

Of the 108 cans on carts on the rails 7 and 8 of the crossing greenhouse, 75 cans were used for characterizing the flowering behavior of new varieties. Sixty-one varieties were of unknown flowering type, and 5 were of known flowering type (Table 3). Natural flowering

This project was partially funded by the American Sugar Cane League.

began on November 24, and observations were conducted through December 16. At that time, all varieties that had not tasseled were examined for signs of induction. By comparing the date of tasseling of new varieties to those of known varieties, a first approximation of the photoperiod response of new varieties was made. Pollen-producing capacity was also observed. No crosses were made with the tassels from cans on rails 7 and 8.

Synchronization of tasseling between the two peaks and across all six bays was not accurate when compared with previous years. The early peak (bays 1-3) predicted average DTFF was 103d, and actual average DTFF was 113d, 10 days late. The late peak (bays 4-6) predicted average DTFF was 130d and actual average DTFF was 120d, 10 days early. The inconsistency was due to a combination of increasing the minimum duration of constant photoperiod prior to starting decling photoperiod and changing dates of beginning decline of photoperiod. Overall flowering was good with a favorable balance of female and male tassels throughout the crossing season. Crossing began on September 11 and ended on November 12. Cool and dry weather conditions in the fall and close attention to conditions in the crossing greenhouse resulted in good seed set, and viable seed. As a result, 288 biparental crosses were made out of 358 total crosses (Table 4). Biparental crosses are favored over poly-crosses due to greater parental control. A summary of varietal response to photoperiod treatments is contained in Table 5. A summary of varietal responses to natural photoperiod is present in Table 6. Lists of crosses made in 1993 are presented in Tables 7, 8, and 9.

Modifications related to crossing include the installation of a drip-type irrigation system to water the airlayered stalks used in crossing. This system was piped into the existing watering system and led to a financial savings in man-hours to water the individual stalks. The computer software (written in the Paradox pal language) used to aid in crossing decisions was further modified to include parental yield and pest resistance data, objective and empirical cross performance data, seed in storage information, and data on whether the cross had been made during the current crossing campaign. Seed storage proceedures were modified from using paper bags to using plastic freezer bags with the addition of silica gel.

Table 1. Summary of 1993 photoperiod treatments.

Bay	Cart	Earliest Start Treatment	Days of Constant Photoperiod	Decline		Bay Heat Status	Target Flower Date
				Date Began	Rate (min d^{-1})		
1	A	July 1	30	July 31	1	no heat	Sept. 30
1	B	June 20	41	July 31	1	no heat	Sept. 30
1	C	June 7	54	July 31	1	no heat	Sept. 30
2	A	June 27	30	July 27	1	heated	Sept. 30
2	B	June 18	39	July 27	1	heated	Sept. 30
2	C	June 2	55	July 27	1	heated	Sept. 30
3	A	June 27	30	July 27	1	heated	Sept. 30
3	B	June 20	37	July 27	1	heated	Sept. 30
3	C	June 16	41	July 27	1	heated	Sept. 30
4	A	June 27	30	July 27	½	heated	Oct. 14
4	B	June 11	46	July 27	½	heated	Oct. 14
4	C	May 20	68	July 27	½	heated	Oct. 14
5	A	June 1	44	July 14	1	heated	Oct. 14
5	B	May 25	50	July 14	1	heated	Oct. 14
5	C	May 25	65	July 29	1	heated	Oct. 14
6	A	May 25	45	July 9	1	heated	Oct. 14
6	B	May 25	45	July 9	1	heated	Oct. 14
6	C	May 25	45	July 9	1	heated	Oct. 14

Table 2. Can, variety, and flower information from carts on bays 1 through 6 of photoperiod house.

Total Cans	Cans Used	Varieties Planted	Varieties Used	Total Stalks	Total Flowers	Mean Stalks Per Can	Mean Flowers Per Can
----------Number----------						-----Number/Can-----	
324	283	110	86	921	701	3.25	2.80

Table 3. Can, variety, and flower information from carts on rails 7 and 8 of crossing greenhouses.

Total Cans	Cans Used	Total Varieties		Varieties Flowering		Mean Stalks Per Can	Mean Flowers Per Can
		Known†	Unknown‡	Known	Unknown		
----------Number----------						----Number/Can----	
108	75	5	61	5	21	3.39	1.76

† Flowering ability is known.
‡ Flowering ability is unknown.

Table 4. Summary of cross number, types and seed production in 1993 sugarcane crossing season.

Type of cross	Number of crosses	Total seed	Mean seed	Mean germination
	----------number----------			---plants/g seed---
Biparental	288	280079	973 ± 1444	112.8 ± 119.6
Poly	21	32461	1545 ± 1631	158.6 ± 123.8
Self†	49	51629	1076 ± 1993	77.8 ± 139.4
Total	358	364169	1020 ± 1540	110.8 ± 123.4

† Note that selfs are made only one time with each parent and only with clones used as males.

Table 5. Summary of varietal responses to 1993 photoperiod treatments.

Variety	Peak	Decline Rate† (min d^{-1})	Days to First Flower‡	Mean Days to Flower	Mean Pollen Rating§	No. of Tassels
CP70-321	EARLY	1.0	130	140.3	8.3	3
CP70-321	LATE	0.5	126	137.7	7.3	5
CP75-1082	EARLY	1.0	96	96.8	3.0	9
CP75-1082	LATE	0.5	106	106.0	1.0	3
CP76-331	EARLY	1.0	89	100.0	2.3	23
CP76-331	LATE	0.5	99	99.0	3.0	2
CP77-405	EARLY	1.0	112	112.0	3.0	1
CP77-405	LATE	0.5	106	106.0	3.0	2
CP79-318	EARLY	1.0	114	121.5	4.6	15
CP79-318	LATE	0.5	122	126.3	7.0	3
CP84-730	LATE	1.0	151	151.0	7.0	1
CP85-845	EARLY	1.0	112	125.2	6.7	23
CP85-845	LATE	0.5	115	120.8	6.3	6
CP85-845	LATE	1.0	120	127.1	5.6	7
CP87-657	LATE	0.5	140	143.3	5.0	4
CP88-739	EARLY	1.0	112	126.3	7.7	12
CP88-769	LATE	1.0	125	125.0	7.0	3
CP89-800	EARLY	1.0	96	109.9	7.9	20
CP89-821	LATE	1.0	122	127.0	9.0	2
CP89-843	LATE	1.0	116	116.0	7.0	4
CP89-846	EARLY	1.0	121	123.5	8.8	22
CP89-846	LATE	0.5	122	137.0	6.0	2
CP89-855	EARLY	1.0	94	103.5	1.5	34
CP89-855	LATE	0.5	115	119.0	3.0	6
CP89-879	EARLY	1.0	140	141.5	8.0	2
CP89-879	LATE	0.5	136	138.5	8.0	2
Ho89-884	LATE	1.0	115	116.8	8.2	5
Ho89-889	LATE	1.0	122	122.0	3.0	2
CP90-935	LATE	1.0	122	125.0	6.5	4
CP90-941	LATE	1.0	105	107.0	9.0	3
CP90-951	LATE	1.0	NONE★	.	.	.
CP90-952	LATE	1.0	120	120.0	7.0	2
CP90-956	LATE	1.0	118	119.0	3.0	2
CP90-957	EARLY	1.0	INDC	.	.	.
CP90-957	LATE	1.0	132	135.7	7.7	3
CP90-962	LATE	1.0	120	120.5	3.0	3
CP90-963	LATE	1.0	127	128.8	3.0	8
CP91-505	LATE	1.0	120	122.3	5.7	3

Table 5. continued.

Variety	Peak	Decline Rate† (min d^{-1})	Days to First Flower‡	Mean Days to Flower	Mean Pollen Rating§	No. of Tassels
CP91-516	LATE	1.0	134	137.5	8.0	2
CP91-523	LATE	1.0	118	119.0	9.0	2
CP91-525	LATE	1.0	113	113.7	3.0	3
CP91-530	LATE	1.0	108	110.7	5.0	3
CP91-531	LATE	1.0	NONE	.	.	.
CP91-532	LATE	1.0	127	127.0	1.0	1
CP91-534	LATE	0.5	131	131.0	3.0	2
CP91-538	LATE	1.0	118	118.0	5.0	1
CP91-552	LATE	0.5	112	112.8	6.0	4
CP91-555	LATE	0.5	INDC	.	.	.
CP91-557	LATE	1.0	115	116.0	9.0	3
CP91-558	LATE	1.0	113	114.0	3.5	2
CP91-559	LATE	1.0	NONE	.	.	.
CP91-566	LATE	1.0	INDC	.	.	.
CP91-567	LATE	1.0	NONE	.	.	.
CP91-568	LATE	1.0	111	111.0	3.0	3
CP91-572	LATE	1.0	118	118.5	3.0	4
CP91-577	EARLY	1.0	96	97.3	7.5	4
LCP81-010	EARLY	1.0	101	104.1	3.5	12
LCP81-010	LATE	0.5	106	106.0	3.0	2
LCP82-089	EARLY	1.0	126	134.8	2.2	10
LCP82-089	LATE	0.5	150	153.3	2.6	10
LCP82-089	LATE	1.0	120	127.4	2.7	23
LCP85-313	EARLY	1.0	106	111.2	7.0	6
LCP85-384	EARLY	1.0	106	118.6	1.7	47
LCP85-384	LATE	0.5	122	132.8	2.1	9
LCP86-429	EARLY	1.0	103	108.5	7.1	14
LCP86-429	LATE	0.5	117	120.5	7.5	4
LCP86-454	EARLY	1.0	94	108.7	4.9	12
LCP86-454	LATE	0.5	108	110.0	3.3	5
LCP87-017	EARLY	1.0	90	98.6	3.8	23
LCP87-017	LATE	0.5	101	105.5	4.0	4
LCP87-491	EARLY	1.0	NONE	.	.	.
LCP87-491	LATE	1.0	NONE	.	.	.
LCP87-494	LATE	0.5	NONE	.	.	.
LHo83-153	LATE	0.5	140	151.0	5.0	2
LHo83-153	LATE	1.0	BOOT	.	.	.

Table 5. continued.

Variety	Peak	Decline Rate† (min d^{-1})	Days to First Flower‡	Mean Days to Flower	Mean Pollen Rating§	No. of Tassels
LHo92-307	EARLY	1.0	109	117.0	1.5	4
L75-020	LATE	1.0	111	114.5	3.0	2
L75-056	EARLY	1.0	92	96.6	4.8	19
L75-056	LATE	0.5	103	103.0	1.0	1
L88-046	LATE	0.5	145	150.5	7.3	12
L88-046	LATE	1.0	120	129.3	6.7	7
L88-063	LATE	0.5	126	143.6	3.0	11
L88-063	LATE	1.0	125	131.8	3.5	4
L89-113	EARLY	1.0	113	122.3	2.7	4
L89-113	LATE	0.5	124	136.3	2.3	3
L89-152	EARLY	1.0	ND	.	.	.
L89-152	LATE	1.0	132	135.3	2.5	4
L90-178	EARLY	1.0	112	127.3	5.1	29
L90-178	LATE	0.5	133	135.7	3.0	3
L90-191	EARLY	1.0	126	138.0	3.3	14
L90-191	LATE	0.5	131	136.0	3.0	2
L91-230	LATE	1.0	120	123.7	7.7	3
L91-232	LATE	1.0	120	120.0	1.0	3
L91-250	LATE	1.0	115	124.3	7.5	5
L91-255	LATE	1.0	108	116.8	5.2	9
L91-261	LATE	1.0	146	149.5	2.0	2
L91-264	LATE	1.0	120	121.8	3.5	4
L91-266	LATE	1.0	122	122.0	3.0	2
L91-276	LATE	1.0	118	119.6	5.4	5
L91-281	LATE	1.0	107	112.2	5.7	6
L91-285	LATE	1.0	139	145.0	2.3	3
L91-286	LATE	1.0	122	132.3	3.5	4
L91-288	LATE	1.0	108	124.7	7.3	6
L91-290	LATE	1.0	127	129.5	7.0	2
L92-292	EARLY	1.0	NONE	.	.	.
L92-353	EARLY	1.0	122	122.0	1.0	2
L92-356	EARLY	1.0	117	119.5	3.0	2
US77-017	EARLY	1.0	103	108.9	7.3	7
US77-017	LATE	0.5	106	110.6	6.7	7
US90-018	EARLY	1.0	151	151.0	5.0	1
US90-018	LATE	1.0	113	122.7	3.5	11
US90-021	EARLY	1.0	147	147.0	3.0	1

Table 5. continued.

Variety	Peak	Decline Rate† (min d^{-1})	Days to First Flower‡	Mean Days to Flower	Mean Pollen Rating§	No. of Tassels
US90-021	LATE	1.0	125	145.3	3.7	8
US90-024	EARLY	1.0	145	148.0	9.0	2
US90-024	LATE	1.0	115	139.0	6.7	5
US90-026	EARLY	1.0	130	130.0	7.0	1
US90-026	LATE	1.0	113	125.5	7.3	6
US90-027	EARLY	1.0	NONE	.	.	.
US90-027	LATE	1.0	113	122.2	2.8	7

† Decline rate is the rate of photoperiod decline after a fixed number of days with a constant photoperiod length.

‡ Days to first flower is calculated as the number of days from the initiation of photoperiod treatments until the first flower of a variety-treatment combination.

§ Pollen rating is visually assigned where 1 = much pollen to 9 = no pollen.

★ ABRT - aborted; BOOT - boot stage; EMGD - emerged; INDC - induced; NONE - no flowering response; ND - no data.

Table 6. Summary of varietal responses to natural photoperiod in 1993.

Variety	First Flower Date†	Mean First Flower Date	Mean Pollen Rating§	Variety	First Flower Date†	Mean First Flower Date	Mean Pollen Rating§
CP65-357	344	344	5.0	L92-323	BOOT	.	.
CP70-330	340	341	9.0	L92-324	NONE	.	.
CP74-383	337	344	6.0	L92-325	337	341	3.0
CP91-500	EMGD‡	.	.	L92-326	NONE	.	.
CP91-502	328	328	7.0	L92-327	NONE	.	.
CP91-506	NONE	.	.	L92-328	335	337	2.3
CP91-527	NONE	.	.	L92-329	NONE	.	.
CP91-542	NONE	.	.	L92-330	NONE	340	9.0
CP91-547	340	340	9.0	L92-331	NONE	.	.
CP91-575	NONE	.	.	L92-332	344	344	7.0
LCP81-030	340	342	3.0	L92-334	INDC	.	.
LCP85-384	335	338	2.8	L92-335	NONE	.	.
LHo92-314	INDC	.	.	L92-336	NONE	.	.
L92-291	NONE	.	.	L92-337	333	333	3.0
L92-293	NONE	.	.	L92-338	349	349	3.0
L92-294	NONE	.	.	L92-339	337	339	7.0
L92-295	NONE	.	.	L92-340	NONE	.	.
L92-299	340	340	9.0	L92-342	340	341	7.7
L92-300	NONE	.	.	L92-343	NONE	.	.
L92-301	NONE	.	.	L92-345	337	337	9.0
L92-302	340	340	3.0	L92-347	344	344	9.0
L92-303	NONE	.	.	L92-348	NONE	.	.
L92-304	NONE	.	.	L92-349	EMGD	.	.
L92-305	EMGD	.	.	L92-350	344	344	7.0
L92-306	349	349	9.0	L92-351	EMGD	.	.
L92-308	351	351	3.0	L92-352	BOOT	.	.
L92-309	340	340	5.0	L92-354	NONE	.	.
L92-310	NONE	.	.	L92-355	EMGD	.	.
L92-311	NONE	.	.	L92-357	NONE	.	.
L92-312	NONE	.	.				
L92-313	347	349	7.0				
L92-315	EMGD	.	.				
L92-316	328	331	8.0				
L92-317	333	333	9.0				
L92-318	NONE	.	.				
L92-321	NONE	.	.				
L92-322	INDC	.	.				

† Julian Date.

‡ ABRT - aborted; BOOT - boot stage; EMGD - emerged; INDC - induced; NONE - no flowering response.

§ Pollen rating is visually assigned where 1=much pollen to 9=no pollen.

Table 7. Crosses and seed made in 1993 sorted by cross number.

Cross	Female	Male	Seed	Cross	Female	Male	Seed
XL93-001	L91-281	L91-255	4705	XL93-052	CP90-956	CP90-956	166
XL93-002	L91-288	L91-255	1077	XL93-053	L91-230	CP76-331	528
XL93-003	CP90-941	L91-255	3497	XL93-054	US90-024	CP76-331	1223
XL93-004	L91-255	L91-255	9089	XL93-055	CP76-331	CP76-331	389
XL93-005	L91-281	93P1	3260	XL93-056	L88-046	Ho89-889	11
XL93-006	CP91-530	93P1	48	XL93-057	CP91-577	Ho89-889	791
XL93-007	L91-288	93P1	341	XL93-058	Ho89-889	Ho89-889	299
XL93-008	CP90-941	93P1	735	XL93-059	US90-026	LCP82-089	1595
XL93-009	US90-027	CP91-558	2878	XL93-060	CP91-577	LCP82-089	1430
XL93-010	CP91-558	CP91-558	242	XL93-061	L91-288	93P3	1031
XL93-011	US90-026	CP91-525	2738	XL93-062	L91-266	93P3	856
XL93-012	L91-255	CP91-525	1804	XL93-063	L91-286	93P3	580
XL93-013	CP91-525	CP91-525	431	XL93-064	CP91-577	CP90-935	72
XL93-014	CP91-530	US90-018	11	XL93-065	CP90-935	CP90-935	21
XL93-015	US90-018	US90-018	2920	XL93-066	CP91-505	US90-018	790
XL93-017	L91-255	US90-018	1833	XL93-067	CP85-845	LCP87-017	166
XL93-018	L91-281	CP91-558	572	XL93-068	CP89-843	LCP87-017	158
XL93-019	Ho89-884	CP91-558	2536	XL93-069	L88-046	LCP87-017	0
XL93-020	CP91-558	CP91-558	801	XL93-070	LCP87-017	LCP87-017	2701
XL93-021	CP91-557	US90-027	30	XL93-071	CP85-845	LCP82-089	243
XL93-022	L91-250	US90-027	884	XL93-072	L88-046	LCP82-089	7
XL93-023	US90-027	US90-027	372	XL93-073	L91-288	LCP82-089	18
XL93-024	CP91-523	CP91-568	285	XL93-074	CP89-843	LCP82-089	162
XL93-025	US90-026	CP91-568	1846	XL93-075	L75-056	LCP87-017	217
XL93-026	L91-281	CP91-568	289	XL93-076	L88-046	L88-063	0
XL93-027	Ho89-884	CP91-568	1360	XL93-077	L75-056	L88-063	22
XL93-028	CP91-568	CP91-568	1966	XL93-078	L88-063	L88-063	174
XL93-029	Ho89-884	L91-255	3870	XL93-079	CP86-429	CP91-505	0
XL93-030	CP91-557	CP91-572	889	XL93-080	L75-056	CP91-505	0
XL93-031	L91-250	CP91-572	1606	XL93-081	CP91-505	CP91-505	8
XL93-032	L91-276	CP91-572	862	XL93-082	L75-056	CP85-845	42
XL93-033	CP91-572	CP91-572	427	XL93-083	CP85-845	CP85-845	57
XL93-034	CP75-20	93P2	2687	XL93-084	LCP81-010	LCP82-089	1978
XL93-035	CP91-538	93P2	1355	XL93-085	L75-020	L75-020	0
XL93-036	CP90-956	93P2	493	XL93-086	LCP87-017	LCP87-017	487
XL93-037	CP90-952	L91-264	578	XL93-087	LCP86-429	CP90-963	274
XL93-038	L91-264	L91-264	956	XL93-088	CP90-963	CP90-963	143
XL93-039	CP91-505	L91-232	346	XL93-089	LCP82-089	93P4	2923
XL93-040	CP90-952	L91-232	659	XL93-090	CP90-963	93P4	877
XL93-041	L91-232	L91-232	2101	XL93-091	CP76-331	93P4	2067
XL93-042	L91-288	LCP82-089	1229	XL93-092	CP91-577	CP76-331	336
XL93-043	LCP82-089	LCP82-089	992	XL93-093	CP90-935	CP76-331	47
XL93-044	US90-026	CP90-962	0	XL93-094	L91-290	CP76-331	97
XL93-045	CP85-845	CP90-962	355	XL93-095	LCP86-429	CP91-532	152
XL93-046	L91-230	CP90-962	57	XL93-096	CP91-532	CP91-532	38
XL93-047	CP90-962	CP90-962	0	XL93-097	LCP86-454	CP89-855	1158
XL93-048	CP91-523	US90-027	279	XL93-098	LCP86-429	CP89-855	715
XL93-049	L91-276	US90-027	992	XL93-099	L75-056	CP89-855	232
XL93-050	L91-276	CP91-572	426	XL93-100	CP89-855	CP89-855	1030
XL93-051	L88-046	CP90-956	71	XL93-101	LCP86-454	LCP87-017	431

Table 7. continued.

Cross	Female	Male	Seed
XL93-102	LCP81-010	CP76-331	2367
XL93-103	LCP86-454	CP76-331	1400
XL93-104	CP89-846	CP76-331	194
XL93-105	CP89-846	LCP87-017	1248
XL93-106	LCP86-429	LCP87-017	367
XL93-107	CP91-552	LCP87-017	4130
XL93-108	L75-056	LCP87-017	274
XL93-109	CP89-846	CP89-855	356
XL93-110	CP90-935	CP89-855	390
XL93-111	CP89-846	CP90-963	202
XL93-112	L91-230	CP90-963	68
XL93-113	L75-056	CP90-963	134
XL93-114	LCP87-017	CP90-963	454
XL93-115	CP89-846	LCP82-089	115
XL93-116	LCP86-454	LCP82-089	538
XL93-117	CP89-800	LCP82-089	180
XL93-118	CP89-846	CP75-1082	801
XL93-119	CP89-800	CP75-1082	745
XL93-120	L75-056	CP75-1082	883
XL93-121	L90-178	CP75-1082	558
XL93-122	CP89-821	CP75-1082	22
XL93-123	CP75-1082	CP75-1082	6579
XL93-124	CP89-855	CP89-855	149
XL93-125	CP89-855	L75-056	18
XL93-126	CP89-846	L75-056	9
XL93-127	L91-250	L75-056	38
XL93-128	L75-056	L75-056	80
XL93-129	CP89-855	93P5	960
XL93-130	CP76-331	93P5	2862
XL93-131	CP75-1082	93P5	7374
XL93-132	L75-056	93P5	1074
XL93-133	LCP81-010	93P5	742
XL93-134	LCP86-454	LCP85-384	2845
XL93-135	US90-024	LCP85-384	351
XL93-136	US90-021	LCP85-384	2468
XL93-137	LCP85-384	LCP85-384	2859
XL93-138	LCP85-384	CP89-855	1884
XL93-139	CP85-845	CP89-855	2429
XL93-140	L90-178	CP89-855	1741
XL93-141	L91-290	CP89-855	624
XL93-142	CP89-855	CP76-331	1392
XL93-143	CP88-769	CP76-331	1768
XL93-144	L75-056	CP76-331	789
XL93-145	LCP86-454	US90-018	1299
XL93-146	CP89-846	US90-018	1512
XL93-147	CP90-957	LCP86-454	819
XL93-148	CP89-846	LCP86-454	1788
XL93-149	LCP86-454	LCP86-454	500
XL93-150	CP90-957	LCP81-010	277
XL93-151	CP89-846	LCP81-010	540
XL93-152	CP88-769	LCP81-010	972
XL93-153	L90-178	LCP81-010	1140
XL93-154	LCP81-010	LCP81-010	7723
XL93-155	LCP85-384	CP90-963	639
XL93-156	L90-178	CP90-963	168
XL93-157	CP76-331	CP90-963	1326
XL93-158	CP89-846	CP91-552	1782
XL93-159	CP89-855	CP91-552	3223
XL93-160	CP91-552	CP91-552	3359
XL93-161	L91-290	CP75-1082	752
XL93-162	CP89-855	CP75-1082	1097
XL93-163	LCP86-429	CP75-1082	3153
XL93-164	LCP85-384	LCP82-089	10213
XL93-165	LCP86-429	LCP82-089	12165
XL93-166	LCP86-454	LCP85-384	2959
XL93-167	CP89-846	LCP85-384	737
XL93-168	LCP87-017	CP89-855	7174
XL93-169	CP89-800	CP89-855	38
XL93-170	LCP82-089	CP89-855	2019
XL93-171	LCP86-429	CP89-855	6844
XL93-172	L90-178	LCP82-089	996
XL93-173	L90-191	LCP82-089	2114
XL93-174	CP76-331	US90-027	2288
XL93-175	CP91-516	US90-027	940
XL93-176	CP89-800	LCP87-017	76
XL93-177	L90-178	LCP87-017	517
XL93-178	LCP85-384	LCP87-017	367
XL93-179	LCP87-017	CP77-405	4089
XL93-180	CP89-800	CP77-405	630
XL93-181	CP77-405	CP77-405	2751
XL93-182	US90-021	CP89-855	309
XL93-183	CP89-846	CP89-855	667
XL93-184	LCP86-429	CP89-855	777
XL93-185	LCP87-017	CP76-331	2003
XL93-186	LCP86-429	CP76-331	347
XL93-187	CP79-318	CP89-855	1109
XL93-188	CP88-739	LCP87-017	493
XL93-189	L91-250	LCP87-017	194
XL93-190	L90-178	US90-027	1969
XL93-191	CP89-846	US90-027	3836
XL93-192	LCP86-454	LCP81-010	3156
XL93-193	CP89-800	LCP81-010	1481
XL93-194	LCP82-089	LCP81-010	3680
XL93-195	L75-056	LCP81-010	3223
XL93-196	CP85-845	CP87-657	69
XL93-197	L90-178	CP87-657	20
XL93-198	CP79-318	CP87-657	101
XL93-199	CP87-657	CP87-657	0
XL93-200	LCP82-089	LCP85-384	1856
XL93-201	LHo83-153	LCP85-384	169

Table 7. continued.

Cross	Female	Male	Seed
XL93-202	CP88-739	LCP85-384	297
XL93-203	CP85-845	LCP85-384	946
XL93-204	US77-017	LCP82-089	332
XL93-205	L75-056	LCP82-089	3115
XL93-206	CP76-331	L75-056	1518
XL93-207	LCP85-384	L75-056	661
XL93-208	L90-178	L75-056	643
XL93-209	CP89-800	LCP85-384	565
XL93-210	L90-191	LCP85-384	747
XL93-211	CP89-846	LCP85-384	1483
XL93-212	US90-024	LCP82-089	0
XL93-213	LCP85-313	LCP82-089	512
XL93-214	LCP86-429	L75-056	691
XL93-215	CP88-739	L91-285	18
XL93-216	CP89-846	L91-285	37
XL93-217	L88-046	L91-285	8
XL93-218	L91-285	L91-285	23
XL93-219	CP79-318	L89-113	317
XL93-220	CP89-800	L89-113	123
XL93-221	LCP85-313	L89-113	48
XL93-222	L89-113	L89-113	76
XL93-223	CP87-657	CP89-855	208
XL93-224	US77-017	CP89-855	150
XL93-225	US77-017	CP76-331	981
XL93-226	L91-286	CP76-331	600
XL93-227	CP87-657	CP76-331	12
XL93-228	L91-286	CP75-1082	50
XL93-229	CP85-845	CP75-1082	3287
XL93-230	L90-178	LCP86-454	1330
XL93-231	CP85-845	LCP86-454	346
XL93-232	CP79-318	L89-152	1887
XL93-233	CP89-846	L89-152	1293
XL93-234	L90-178	L89-152	509
XL93-235	L89-152	L89-152	380
XL93-236	L90-178	L88-063	324
XL93-237	CP85-845	L88-063	1603
XL93-238	L90-178	CP77-405	289
XL93-239	L88-046	CP89-855	144
XL93-240	L88-046	CP76-331	129
XL93-241	CP85-845	CP76-331	738
XL93-242	CP88-739	CP76-331	171
XL93-243	CP85-845	L92-356	209
XL93-244	L88-046	L92-356	131
XL93-245	L92-356	L92-356	88
XL93-246	L88-046	LCP85-384	279
XL93-247	US77-017	LCP85-384	910
XL93-248	CP91-516	LCP85-384	1023
XL93-249	CP89-846	LCP86-454	794
XL93-250	L88-046	L89-113	71
XL93-251	CP89-846	L89-113	497
XL93-252	CP89-846	L88-063	93
XL93-253	CP88-739	L88-063	441
XL93-254	CP79-318	L88-063	1027
XL93-255	CP85-845	L89-152	603
XL93-256	CP70-321	L88-063	128
XL93-257	CP90-957	L88-063	11
XL93-258	CP70-321	LCP85-384	330
XL93-259	LCP85-313	LCP85-384	174
XL93-260	US90-026	LCP85-384	985
XL93-261	CP85-845	L90-178	202
XL93-262	L88-046	L90-178	0
XL93-263	CP89-800	L90-178	172
XL93-264	CP79-318	L90-178	771
XL93-265	L90-178	L90-178	563
XL93-266	LCP86-429	LCP82-089	345
XL93-267	L88-046	US77-017	210
XL93-268	US77-017	US77-017	152
XL93-269	L90-178	93P6	329
XL93-270	LCP85-384	93P6	978
XL93-271	CP89-855	93P6	889
XL93-272	LCP86-454	L89-113	642
XL93-273	L88-046	L89-113	62
XL93-274	L88-046	LCP85-384	179
XL93-275	LCP87-017	LCP85-384	628
XL93-276	US90-021	LCP85-384	827
XL93-277	CP87-657	LCP82-089	749
XL93-278	US77-017	LHo92-307	1482
XL93-279	CP79-318	LHo92-307	1925
XL93-280	LHo92-307	LHo92-307	115
XL93-281	CP79-318	US90-021	4521
XL93-282	US77-017	US90-021	384
XL93-283	US90-021	US90-021	188
XL93-284	CP79-318	L92-356	191
XL93-285	US77-017	L90-178	219
XL93-286	CP79-318	L92-353	955
XL93-287	US77-017	L92-353	152
XL93-288	CP89-800	L92-353	147
XL93-289	L92-353	L92-353	27
XL93-290	CP79-318	L91-261	763
XL93-291	US77-017	L91-261	716
XL93-293	CP79-318	L90-191	1832
XL93-294	US77-017	L90-191	585
XL93-295	L90-191	L90-191	92
XL93-296	CP85-845	LHo92-307	289
XL93-297	LCP85-313	L90-178	405
XL93-298	LCP86-454	L88-063	101
XL93-299	LCP87-017	L88-063	506
XL93-300	CP79-318	L88-063	917
XL93-301	US77-017	LCP85-384	1623
XL93-302	CP85-845	L90-191	1310

Table 7. continued.

Cross	Female	Male	Seed
XL93-303	L88-046	L90-191	71
XL93-304	CP70-321	LCP85-384	439
XL93-305	CP85-845	CP76-331	1679
XL93-306	CP85-845	CP89-855	2628
XL93-307	CP79-318	CP89-855	6724
XL93-308	US77-017	L90-178	247
XL93-309	L90-191	CP89-855	5170
XL93-310	CP70-321	CP89-855	233
XL93-311	CP89-879	LCP85-384	750
XL93-312	CP85-845	LCP85-384	3175
XL93-313	CP88-739	LCP82-089	961
XL93-314	CP85-845	L88-046	160
XL93-315	L90-178	L88-046	221
XL93-316	CP88-739	L88-046	46
XL93-317	CP89-800	L88-046	25
XL93-318	L88-046	L88-046	16
XL93-319	LCP85-313	LHo92-307	99
XL93-320	CP89-800	LHo92-307	323
XL93-321	CP85-845	L91-261	1007
XL93-322	L90-191	L91-261	271
XL93-323	CP89-800	L91-285	34
XL93-324	CP85-845	L89-113	135
XL93-325	LCP85-313	CP79-318	37
XL93-326	US90-024	CP79-318	172
XL93-327	LHo83-153	LCP82-089	481
XL93-328	CP70-321	LCP82-089	516
XL93-329	CP88-739	L90-178	38
XL93-330	CP89-879	L90-178	257
XL93-331	CP70-321	L90-178	0
XL93-332	CP85-845	L90-178	617
XL93-333	US90-024	L90-191	72
XL93-334	CP89-800	L90-191	279
XL93-335	CP70-321	L90-191	0
XL93-336	CP88-739	LCP85-384	643
XL93-337	CP85-845	US90-021	1963
XL93-338	CP84-730	CP79-318	39
XL93-339	CP85-845	CP79-318	653
XL93-340	CP79-318	CP79-318	50
XL93-341	CP88-739	CP85-845	643
XL93-342	LCP86-454	L90-178	228
XL93-343	US90-024	L90-178	21
XL93-344	CP89-800	CP91-534	111
XL93-345	CP85-845	CP91-534	3088
XL93-346	CP91-534	CP91-534	36
XL93-347	US90-024	L89-113	21
XL93-348	CP89-879	LCP82-089	2205
XL93-349	US90-018	LCP85-384	320
XL93-350	L91-288	LCP85-384	58
XL93-351	CP88-739	LCP86-429	58
XL93-352	L88-046	LCP86-429	14
XL93-353	LCP86-429	LCP86-429	13
XL93-354	US90-026	LCP85-384	571
XL93-355	CP89-879	LHo92-307	772
XL93-356	CP85-845	LHo92-307	600
XL93-357	CP89-846	CP76-331	187
XL93-358	CP89-800	CP85-845	36
XL93-359	CP88-739	L89-113	0
			====
			364169

Table 8. Crosses and seed made in 1993 sorted by female parent.

Cross	Female	Male	Seed
XL93-331	CP70-321	L90-178	0
XL93-258	CP70-321	LCP85-384	330
XL93-335	CP70-321	L90-191	0
XL93-328	CP70-321	LCP82-089	516
XL93-304	CP70-321	LCP85-384	439
XL93-310	CP70-321	CP89-855	233
XL93-256	CP70-321	L88-063	128
XL93-123	CP75-1082	CP75-1082	6579
XL93-131	CP75-1082	93P5	7374
XL93-034	CP75-20	93P2	2687
XL93-055	CP76-331	CP76-331	389
XL93-130	CP76-331	93P5	2862
XL93-206	CP76-331	L75-056	1518
XL93-091	CP76-331	93P4	2067
XL93-174	CP76-331	US90-027	2288
XL93-157	CP76-331	CP90-963	1326
XL93-181	CP77-405	CP77-405	2751
XL93-290	CP79-318	L91-261	763
XL93-232	CP79-318	L89-152	1887
XL93-300	CP79-318	L88-063	917
XL93-307	CP79-318	CP89-855	6724
XL93-293	CP79-318	L90-191	1832

Table 8. continued.

Cross	Female	Male	Seed
XL93-254	CP79-318	L88-063	1027
XL93-198	CP79-318	CP87-657	101
XL93-264	CP79-318	L90-178	771
XL93-340	CP79-318	CP79-318	50
XL93-187	CP79-318	CP89-855	1109
XL93-279	CP79-318	LHo92-307	1925
XL93-219	CP79-318	L89-113	317
XL93-286	CP79-318	L92-353	955
XL93-284	CP79-318	L92-356	191
XL93-281	CP79-318	US90-021	4521
XL93-338	CP84-730	CP79-318	39
XL93-255	CP85-845	L89-152	603
XL93-261	CP85-845	L90-178	202
XL93-203	CP85-845	LCP85-384	946
XL93-071	CP85-845	LCP82-089	243
XL93-196	CP85-845	CP87-657	69
XL93-139	CP85-845	CP89-855	2429
XL93-083	CP85-845	CP85-845	57
XL93-067	CP85-845	LCP87-017	166
XL93-241	CP85-845	CP76-331	738
XL93-243	CP85-845	L92-356	209
XL93-237	CP85-845	L88-063	1603
XL93-229	CP85-845	CP75-1082	3287
XL93-231	CP85-845	LCP86-454	346
XL93-314	CP85-845	L88-046	160
XL93-339	CP85-845	CP79-318	653
XL93-345	CP85-845	CP91-534	3088
XL93-312	CP85-845	LCP85-384	3175
XL93-332	CP85-845	L90-178	617
XL93-324	CP85-845	L89-113	135
XL93-337	CP85-845	US90-021	1963
XL93-321	CP85-845	L91-261	1007
XL93-306	CP85-845	CP89-855	2628
XL93-296	CP85-845	LHo92-307	289
XL93-356	CP85-845	LHo92-307	600
XL93-045	CP85-845	CP90-962	355
XL93-302	CP85-845	L90-191	1310
XL93-305	CP85-845	CP76-331	1679
XL93-079	CP86-429	CP91-505	0
XL93-277	CP87-657	LCP82-089	749
XL93-199	CP87-657	CP87-657	0
XL93-227	CP87-657	CP76-331	12
XL93-223	CP87-657	CP89-855	208
XL93-351	CP88-739	LCP86-429	58
XL93-359	CP88-739	L89-113	0
XL93-202	CP88-739	LCP85-384	297
XL93-336	CP88-739	LCP85-384	643
XL93-188	CP88-739	LCP87-017	493
XL93-341	CP88-739	CP85-845	643
XL93-215	CP88-739	L91-285	18
XL93-316	CP88-739	L88-046	46
XL93-242	CP88-739	CP76-331	171
XL93-253	CP88-739	L88-063	441
XL93-313	CP88-739	LCP82-089	961
XL93-329	CP88-739	L90-178	38
XL93-143	CP88-769	CP76-331	1768
XL93-152	CP88-769	LCP81-010	972
XL93-344	CP89-800	CP91-534	111
XL93-119	CP89-800	CP75-1082	745
XL93-117	CP89-800	LCP82-089	180
XL93-263	CP89-800	L90-178	172
XL93-288	CP89-800	L92-353	147
XL93-358	CP89-800	CP85-845	36
XL93-193	CP89-800	LCP81-010	1481
XL93-320	CP89-800	LHo92-307	323
XL93-334	CP89-800	L90-191	279
XL93-323	CP89-800	L91-285	34
XL93-209	CP89-800	LCP85-384	565
XL93-176	CP89-800	LCP87-017	76
XL93-169	CP89-800	CP89-855	38
XL93-180	CP89-800	CP77-405	630
XL93-220	CP89-800	L89-113	123
XL93-317	CP89-800	L88-046	25
XL93-122	CP89-821	CP75-1082	22
XL93-068	CP89-843	LCP87-017	158
XL93-074	CP89-843	LCP82-089	162
XL93-183	CP89-846	CP89-855	667
XL93-115	CP89-846	LCP82-089	115
XL93-233	CP89-846	L89-152	1293
XL93-167	CP89-846	LCP85-384	737
XL93-111	CP89-846	CP90-963	202
XL93-216	CP89-846	L91-285	37
XL93-211	CP89-846	LCP85-384	1483
XL93-118	CP89-846	CP75-1082	801
XL93-191	CP89-846	US90-027	3836
XL93-126	CP89-846	L75-056	o
XL93-158	CP89-846	CP91-552	1782
XL93-148	CP89-846	LCP86-454	1788
XL93-249	CP89-846	LCP86-454	794
XL93-151	CP89-846	LCP81-010	540
XL93-252	CP89-846	L88-063	93
XL93-357	CP89-846	CP76-331	187
XL93-251	CP89-846	L89-113	497
XL93-146	CP89-846	US90-018	1512
XL93-109	CP89-846	CP89-855	356
XL93-104	CP89-846	CP76-331	194
XL93-105	CP89-846	LCP87-017	1248
XL93-162	CP89-855	CP75-1082	1097
XL93-159	CP89-855	CP91-552	3223
XL93-142	CP89-855	CP76-331	1392

Table 8. continued.

Cross	Female	Male	Seed
XL93-129	CP89-855	93P5	960
XL93-125	CP89-855	L75-056	18
XL93-271	CP89-855	93P6	889
XL93-100	CP89-855	CP89-855	1030
XL93-124	CP89-855	CP89-855	149
XL93-348	CP89-879	LCP82-089	2205
XL93-355	CP89-879	LHo92-307	772
XL93-311	CP89-879	LCP85-384	750
XL93-330	CP89-879	L90-178	257
XL93-093	CP90-935	CP76-331	47
XL93-110	CP90-935	CP89-855	390
XL93-065	CP90-935	CP90-935	21
XL93-003	CP90-941	L91-255	3497
XL93-008	CP90-941	93P1	735
XL93-040	CP90-952	L91-232	659
XL93-037	CP90-952	L91-264	578
XL93-052	CP90-956	CP90-956	166
XL93-036	CP90-956	93P2	493
XL93-257	CP90-957	L88-063	11
XL93-150	CP90-957	LCP81-010	277
XL93-147	CP90-957	LCP86-454	819
XL93-047	CP90-962	CP90-962	0
XL93-088	CP90-963	CP90-963	143
XL93-090	CP90-963	93P4	877
XL93-081	CP91-505	CP91-505	8
XL93-066	CP91-505	US90-018	790
XL93-039	CP91-505	L91-232	346
XL93-248	CP91-516	LCP85-384	1023
XL93-175	CP91-516	US90-027	940
XL93-048	CP91-523	US90-027	279
XL93-024	CP91-523	CP91-568	285
XL93-013	CP91-525	CP91-525	431
XL93-006	CP91-530	93P1	48
XL93-014	CP91-530	US90-018	11
XL93-096	CP91-532	CP91-532	38
XL93-346	CP91-534	CP91-534	36
XL93-035	CP91-538	93P2	1355
XL93-107	CP91-552	LCP87-017	4130
XL93-160	CP91-552	CP91-552	3359
XL93-030	CP91-557	CP91-572	889
XL93-021	CP91-557	US90-027	30
XL93-020	CP91-558	CP91-558	801
XL93-010	CP91-558	CP91-558	242
XL93-028	CP91-568	CP91-568	1966
XL93-033	CP91-572	CP91-572	427
XL93-060	CP91-577	LCP82-089	1430
XL93-064	CP91-577	CP90-935	72
XL93-092	CP91-577	CP76-331	336
XL93-057	CP91-577	Ho89-889	791
XL93-019	Ho89-884	CP91-558	2536
XL93-029	Ho89-884	L91-255	3870
XL93-027	Ho89-884	CP91-568	1360
XL93-058	Ho89-889	Ho89-889	299
XL93-085	L75-020	L75-020	0
XL93-132	L75-056	93P5	1074
XL93-077	L75-056	L88-063	22
XL93-080	L75-056	CP91-505	0
XL93-099	L75-056	CP89-855	232
XL93-205	L75-056	LCP82-089	3115
XL93-195	L75-056	LCP81-010	3223
XL93-113	L75-056	CP90-963	134
XL93-075	L75-056	LCP87-017	217
XL93-120	L75-056	CP75-1082	883
XL93-108	L75-056	LCP87-017	274
XL93-144	L75-056	CP76-331	789
XL93-128	L75-056	L75-056	80
XL93-082	L75-056	CP85-845	42
XL93-274	L88-046	LCP85-384	179
XL93-069	L88-046	LCP87-017	0
XL93-273	L88-046	L89-113	62
XL93-217	L88-046	L91-285	8
XL93-051	L88-046	CP90-956	71
XL93-244	L88-046	L92-356	131
XL93-246	L88-046	LCP85-384	279
XL93-250	L88-046	L89-113	71
XL93-352	L88-046	LCP86-429	14
XL93-262	L88-046	L90-178	0
XL93-267	L88-046	US77-017	210
XL93-239	L88-046	CP89-855	144
XL93-056	L88-046	Ho89-889	11
XL93-240	L88-046	CP76-331	129
XL93-303	L88-046	L90-191	71
XL93-076	L88-046	L88-063	0
XL93-072	L88-046	LCP82-089	7
XL93-318	L88-046	L88-046	16
XL93-078	L88-063	L88-063	174
XL93-222	L89-113	L89-113	76
XL93-235	L89-152	L89-152	380
XL93-230	L90-178	LCP86-454	1330
XL93-265	L90-178	L90-178	563
XL93-156	L90-178	CP90-963	168
XL93-172	L90-178	LCP82-089	996
XL93-140	L90-178	CP89-855	1741
XL93-315	L90-178	L88-046	221
XL93-238	L90-178	CP77-405	289
XL93-177	L90-178	LCP87-017	517
XL93-234	L90-178	L89-152	509
XL93-236	L90-178	L88-063	324
XL93-153	L90-178	LCP81-010	1140
XL93-269	L90-178	93P6	329

Table 8. continued.

Cross	Female	Male	Seed
XL93-197	L90-178	CP87-657	20
XL93-121	L90-178	CP75-1082	558
XL93-208	L90-178	L75-056	643
XL93-190	L90-178	US90-027	1969
XL93-210	L90-191	LCP85-384	747
XL93-173	L90-191	LCP82-089	2114
XL93-322	L90-191	L91-261	271
XL93-309	L90-191	CP89-855	5170
XL93-295	L90-191	L90-191	92
XL93-046	L91-230	CP90-962	57
XL93-053	L91-230	CP76-331	528
XL93-112	L91-230	CP90-963	68
XL93-041	L91-232	L91-232	2101
XL93-031	L91-250	CP91-572	1606
XL93-127	L91-250	L75-056	38
XL93-022	L91-250	US90-027	884
XL93-189	L91-250	LCP87-017	194
XL93-012	L91-255	CP91-525	1804
XL93-017	L91-255	US90-018	1833
XL93-004	L91-255	L91-255	9089
XL93-038	L91-264	L91-264	956
XL93-062	L91-266	93P3	856
XL93-049	L91-276	US90-027	992
XL93-032	L91-276	CP91-572	862
XL93-050	L91-276	CP91-572	426
XL93-001	L91-281	L91-255	4705
XL93-005	L91-281	93P1	3260
XL93-018	L91-281	CP91-558	572
XL93-026	L91-281	CP91-568	289
XL93-218	L91-285	L91-285	23
XL93-228	L91-286	CP75-1082	50
XL93-063	L91-286	93P3	580
XL93-226	L91-286	CP76-331	600
XL93-042	L91-288	LCP82-089	1229
XL93-002	L91-288	L91-255	1077
XL93-073	L91-288	LCP82-089	18
XL93-007	L91-288	93P1	341
XL93-061	L91-288	93P3	1031
XL93-350	L91-288	LCP85-384	58
XL93-141	L91-290	CP89-855	624
XL93-161	L91-290	CP75-1082	752
XL93-094	L91-290	CP76-331	97
XL93-289	L92-353	L92-353	27
XL93-245	L92-356	L92-356	88
XL93-084	LCP81-010	LCP82-089	1978
XL93-102	LCP81-010	CP76-331	2367
XL93-133	LCP81-010	93P5	742
XL93-154	LCP81-010	LCP81-010	7723
XL93-200	LCP82-089	LCP85-384	1856
XL93-194	LCP82-089	LCP81-010	3680
XL93-170	LCP82-089	CP89-855	2019
XL93-043	LCP82-089	LCP82-089	992
XL93-089	LCP82-089	93P4	2923
XL93-319	LCP85-313	LHo92-307	99
XL93-213	LCP85-313	LCP82-089	512
XL93-259	LCP85-313	LCP85-384	174
XL93-297	LCP85-313	L90-178	405
XL93-325	LCP85-313	CP79-318	37
XL93-221	LCP85-313	L89-113	48
XL93-270	LCP85-384	93P6	978
XL93-155	LCP85-384	CP90-963	639
XL93-178	LCP85-384	LCP87-017	367
XL93-138	LCP85-384	CP89-855	1884
XL93-137	LCP85-384	LCP85-384	2859
XL93-164	LCP85-384	LCP82-089	10213
XL93-207	LCP85-384	L75-056	661
XL93-165	LCP86-429	LCP82-089	12165
XL93-087	LCP86-429	CP90-963	274
XL93-184	LCP86-429	CP89-855	777
XL93-266	LCP86-429	LCP82-089	345
XL93-186	LCP86-429	CP76-331	347
XL93-106	LCP86-429	LCP87-017	367
XL93-095	LCP86-429	CP91-532	152
XL93-214	LCP86-429	L75-056	691
XL93-171	LCP86-429	CP89-855	6844
XL93-163	LCP86-429	CP75-1082	3153
XL93-353	LCP86-429	LCP86-429	13
XL93-098	LCP86-429	CP89-855	715
XL93-166	LCP86-454	LCP85-384	2959
XL93-097	LCP86-454	CP89-855	1158
XL93-342	LCP86-454	L90-178	228
XL93-116	LCP86-454	LCP82-089	538
XL93-272	LCP86-454	L89-113	642
XL93-103	LCP86-454	CP76-331	1400
XL93-134	LCP86-454	LCP85-384	2845
XL93-298	LCP86-454	L88-063	101
XL93-149	LCP86-454	LCP86-454	500
XL93-192	LCP86-454	LCP81-010	3156
XL93-101	LCP86-454	LCP87-017	431
XL93-145	LCP86-454	US90-018	1299
XL93-114	LCP87-017	CP90-963	454
XL93-179	LCP87-017	CP77-405	4089
XL93-299	LCP87-017	L88-063	506
XL93-185	LCP87-017	CP76-331	2003
XL93-070	LCP87-017	LCP87-017	2701
XL93-168	LCP87-017	CP89-855	7174
XL93-275	LCP87-017	LCP85-384	628
XL93-086	LCP87-017	LCP87-017	487
XL93-201	LHo83-153	LCP85-384	169
XL93-327	LHo83-153	LCP82-089	481

Table 8. continued.

Cross	Female	Male	Seed
XL93-280	LHo92-307	LHo92-307	115
XL93-285	US77-017	L90-178	219
XL93-287	US77-017	L92-353	152
XL93-204	US77-017	LCP82-089	332
XL93-282	US77-017	US90-021	384
XL93-278	US77-017	LHo92-307	1482
XL93-247	US77-017	LCP85-384	910
XL93-225	US77-017	CP76-331	981
XL93-294	US77-017	L90-191	585
XL93-291	US77-017	L91-261	716
XL93-301	US77-017	LCP85-384	1623
XL93-268	US77-017	US77-017	152
XL93-224	US77-017	CP89-855	150
XL93-308	US77-017	L90-178	247
XL93-015	US90-018	US90-018	2920
XL93-349	US90-018	LCP85-384	320
XL93-276	US90-021	LCP85-384	827
XL93-182	US90-021	CP89-855	309
XL93-283	US90-021	US90-021	188
XL93-136	US90-021	LCP85-384	2468
XL93-333	US90-024	L90-191	72
XL93-212	US90-024	LCP82-089	0
XL93-054	US90-024	CP76-331	1223
XL93-135	US90-024	LCP85-384	351
XL93-343	US90-024	L90-178	21
XL93-326	US90-024	CP79-318	172
XL93-347	US90-024	L89-113	21
XL93-354	US90-026	LCP85-384	571
XL93-011	US90-026	CP91-525	2738
XL93-025	US90-026	CP91-568	1846
XL93-044	US90-026	CP90-962	0
XL93-260	US90-026	LCP85-384	985
XL93-059	US90-026	LCP82-089	1595
XL93-009	US90-027	CP91-558	2878
XL93-023	US90-027	US90-027	372
			====
			364169

Table 9. Crosses and seed made in 1993 sorted by male parent.

Cross	Female	Male	Seed
XL93-005	L91-281	93P1	3260
XL93-007	L91-288	93P1	341
XL93-008	CP90-941	93P1	735
XL93-006	CP91-530	93P1	48
XL93-034	CP75-20	93P2	2687
XL93-035	CP91-538	93P2	1355
XL93-036	CP90-956	93P2	493
XL93-061	L91-288	93P3	1031
XL93-062	L91-266	93P3	856
XL93-063	L91-286	93P3	580
XL93-090	CP90-963	93P4	877
XL93-091	CP76-331	93P4	2067
XL93-089	LCP82-089	93P4	2923
XL93-133	LCP81-010	93P5	742
XL93-131	CP75-1082	93P5	7374
XL93-129	CP89-855	93P5	960
XL93-130	CP76-331	93P5	2862
XL93-132	L75-056	93P5	1074
XL93-270	LCP85-384	93P6	978
XL93-269	L90-178	93P6	329
XL93-271	CP89-855	93P6	889
XL93-120	L75-056	CP75-1082	883
XL93-228	L91-286	CP75-1082	50
XL93-123	CP75-1082	CP75-1082	6579
XL93-118	CP89-846	CP75-1082	801
XL93-122	CP89-821	CP75-1082	22
XL93-162	CP89-855	CP75-1082	1097
XL93-161	L91-290	CP75-1082	752
XL93-229	CP85-845	CP75-1082	3287
XL93-163	LCP86-429	CP75-1082	3153
XL93-121	L90-178	CP75-1082	558
XL93-119	CP89-800	CP75-1082	745
XL93-054	US90-024	CP76-331	1223
XL93-226	L91-286	CP76-331	600
XL93-094	L91-290	CP76-331	97
XL93-143	CP88-769	CP76-331	1768
XL93-240	L88-046	CP76-331	129
XL93-144	L75-056	CP76-331	789
XL93-092	CP91-577	CP76-331	336
XL93-093	CP90-935	CP76-331	47
XL93-305	CP85-845	CP76-331	1679
XL93-225	US77-017	CP76-331	981
XL93-053	L91-230	CP76-331	528
XL93-242	CP88-739	CP76-331	171

Table 9. continued.

Cross	Female	Male	Seed
XL93-227	CP87-657	CP76-331	12
XL93-055	CP76-331	CP76-331	389
XL93-104	CP89-846	CP76-331	194
XL93-185	LCP87-017	CP76-331	2003
XL93-186	LCP86-429	CP76-331	347
XL93-142	CP89-855	CP76-331	1392
XL93-357	CP89-846	CP76-331	187
XL93-241	CP85-845	CP76-331	738
XL93-102	LCP81-010	CP76-331	2367
L93-103	LCP86-454	CP76-331	1400
XL93-181	CP77-405	CP77-405	2751
XL93-180	CP89-800	CP77-405	630
XL93-238	L90-178	CP77-405	289
XL93-179	LCP87-017	CP77-405	4089
XL93-340	CP79-318	CP79-318	50
XL93-326	US90-024	CP79-318	172
XL93-339	CP85-845	CP79-318	653
XL93-325	LCP85-313	CP79-318	37
XL93-338	CP84-730	CP79-318	39
XL93-082	L75-056	CP85-845	42
XL93-083	CP85-845	CP85-845	57
XL93-341	CP88-739	CP85-845	643
XL93-358	CP89-800	CP85-845	36
XL93-197	L90-178	CP87-657	20
XL93-198	CP79-318	CP87-657	101
XL93-199	CP87-657	CP87-657	0
XL93-196	CP85-845	CP87-657	69
XL93-099	L75-056	CP89-855	232
XL93-109	CP89-846	CP89-855	356
XL93-183	CP89-846	CP89-855	667
XL93-224	US77-017	CP89-855	150
XL93-168	LCP87-017	CP89-855	7174
XL93-310	CP70-321	CP89-855	233
XL93-169	CP89-800	CP89-855	38
XL93-110	CP90-935	CP89-855	390
XL93-307	CP79-318	CP89-855	6724
XL93-184	LCP86-429	CP89-855	777
XL93-138	LCP85-384	CP89-855	1884
XL93-171	LCP86-429	CP89-855	6844
XL93-100	CP89-855	CP89-855	1030
XL93-306	CP85-845	CP89-855	2628
XL93-170	LCP82-089	CP89-855	2019
XL93-141	L91-290	CP89-855	624
XL93-139	CP85-845	CP89-855	2429
XL93-182	US90-021	CP89-855	309
XL93-223	CP87-657	CP89-855	208
XL93-098	LCP86-429	CP89-855	715
XL93-124	CP89-855	CP89-855	149
XL93-097	LCP86-454	CP89-855	1158
XL93-239	L88-046	CP89-855	144
XL93-309	L90-191	CP89-855	5170
XL93-187	CP79-318	CP89-855	1109
XL93-140	L90-178	CP89-855	1741
XL93-064	CP91-577	CP90-935	72
XL93-065	CP90-935	CP90-935	21
XL93-052	CP90-956	CP90-956	166
XL93-051	L88-046	CP90-956	71
XL93-046	L91-230	CP90-962	57
XL93-045	CP85-845	CP90-962	355
XL93-044	US90-026	CP90-962	0
XL93-047	CP90-962	CP90-962	0
XL93-155	LCP85-384	CP90-963	639
XL93-111	CP89-846	CP90-963	202
XL93-087	LCP86-429	CP90-963	274
XL93-157	CP76-331	CP90-963	1326
XL93-114	LCP87-017	CP90-963	454
XL93-156	L90-178	CP90-963	168
XL93-113	L75-056	CP90-963	134
XL93-112	L91-230	CP90-963	68
XL93-088	CP90-963	CP90-963	143
XL93-081	CP91-505	CP91-505	8
XL93-080	L75-056	CP91-505	0
XL93-079	CP86-429	CP91-505	0
XL93-012	L91-255	CP91-525	1804
XL93-013	CP91-525	CP91-525	431
XL93-011	US90-026	CP91-525	2738
XL93-096	CP91-532	CP91-532	38
XL93-095	LCP86-429	CP91-532	152
XL93-344	CP89-800	CP91-534	111
XL93-346	CP91-534	CP91-534	36
XL93-345	CP85-845	CP91-534	3088
XL93-160	CP91-552	CP91-552	3359
XL93-159	CP89-855	CP91-552	3223
XL93-158	CP89-846	CP91-552	1782
XL93-010	CP91-558	CP91-558	242
XL93-009	US90-027	CP91-558	2878
XL93-018	L91-281	CP91-558	572
XL93-019	Ho89-884	CP91-558	2536
XL93-020	CP91-558	CP91-558	801
XL93-027	Ho89-884	CP91-568	1360
XL93-028	CP91-568	CP91-568	1966
XL93-024	CP91-523	CP91-568	285
XL93-026	L91-281	CP91-568	289
XL93-025	US90-026	CP91-568	1846
XL93-050	L91-276	CP91-572	426
XL93-033	CP91-572	CP91-572	427
XL93-031	L91-250	CP91-572	1606
XL93-030	CP91-557	CP91-572	889
XL93-032	L91-276	CP91-572	862
XL93-056	L88-046	Ho89-889	11

Table 9. continued.

Cross	Female	Male	Seed
XL93-058	Ho89-889	Ho89-889	299
XL93-057	CP91-577	Ho89-889	791
XL93-085	L75-020	L75-020	0
XL93-207	LCP85-384	L75-056	661
XL93-214	LCP86-429	L75-056	691
XL93-206	CP76-331	L75-056	1518
XL93-128	L75-056	L75-056	80
XL93-208	L90-178	L75-056	643
XL93-127	L91-250	L75-056	38
XL93-126	CP89-846	L75-056	9
XL93-125	CP89-855	L75-056	18
XL93-317	CP89-800	L88-046	25
XL93-318	L88-046	L88-046	16
XL93-314	CP85-845	L88-046	160
XL93-315	L90-178	L88-046	221
XL93-316	CP88-739	L88-046	46
XL93-256	CP70-321	L88-063	128
XL93-257	CP90-957	L88-063	11
XL93-252	CP89-846	L88-063	93
XL93-236	L90-178	L88-063	324
XL93-076	L88-046	L88-063	0
XL93-253	CP88-739	L88-063	441
XL93-078	L88-063	L88-063	174
XL93-077	L75-056	L88-063	22
XL93-237	CP85-845	L88-063	1603
XL93-254	CP79-318	L88-063	1027
XL93-298	LCP86-454	L88-063	101
XL93-300	CP79-318	L88-063	917
XL93-299	LCP87-017	L88-063	506
XL93-251	CP89-846	L89-113	497
XL93-273	L88-046	L89-113	62
XL93-250	L88-046	L89-113	71
XL93-272	LCP86-454	L89-113	642
XL93-219	CP79-318	L89-113	317
XL93-359	CP88-739	L89-113	0
XL93-324	CP85-845	L89-113	135
XL93-221	LCP85-313	L89-113	48
XL93-222	L89-113	L89-113	76
XL93-347	US90-024	L89-113	21
XL93-220	CP89-800	L89-113	123
XL93-255	CP85-845	L89-152	603
XL93-234	L90-178	L89-152	509
XL93-233	CP89-846	L89-152	1293
XL93-235	L89-152	L89-152	380
XL93-232	CP79-318	L89-152	1887
XL93-332	CP85-845	L90-178	617
XL93-330	CP89-879	L90-178	257
XL93-285	US77-017	L90-178	219
XL93-262	L88-046	L90-178	0
XL93-264	CP79-318	L90-178	771
XL93-342	LCP86-454	L90-178	228
XL93-343	US90-024	L90-178	21
XL93-331	CP70-321	L90-178	0
XL93-263	CP89-800	L90-178	172
XL93-297	LCP85-313	L90-178	405
XL93-308	US77-017	L90-178	247
XL93-261	CP85-845	L90-178	202
XL93-329	CP88-739	L90-178	38
XL93-265	L90-178	L90-178	563
XL93-295	L90-191	L90-191	92
XL93-302	CP85-845	L90-191	1310
XL93-334	CP89-800	L90-191	279
XL93-293	CP79-318	L90-191	1832
XL93-335	CP70-321	L90-191	0
XL93-333	US90-024	L90-191	72
XL93-294	US77-017	L90-191	585
XL93-303	L88-046	L90-191	71
XL93-041	L91-232	L91-232	2101
XL93-039	CP91-505	L91-232	346
XL93-040	CP90-952	L91-232	659
XL93-003	CP90-941	L91-255	3497
XL93-004	L91-255	L91-255	9089
XL93-002	L91-288	L91-255	1077
XL93-001	L91-281	L91-255	4705
XL93-029	Ho89-884	L91-255	3870
XL93-290	CP79-318	L91-261	763
XL93-322	L90-191	L91-261	271
XL93-321	CP85-845	L91-261	1007
XL93-291	US77-017	L91-261	716
XL93-037	CP90-952	L91-264	578
XL93-038	L91-264	L91-264	956
XL93-323	CP89-800	L91-285	34
XL93-215	CP88-739	L91-285	18
XL93-218	L91-285	L91-285	23
XL93-216	CP89-846	L91-285	37
XL93-217	L88-046	L91-285	2
XL93-288	CP89-800	L92-353	147
XL93-286	CP79-318	L92-353	955
XL93-287	US77-017	L92-353	152
XL93-289	L92-353	L92-353	27
XL93-244	L88-046	L92-356	131
XL93-284	CP79-318	L92-356	191
XL93-243	CP85-845	L92-356	209
XL93-245	L92-356	L92-356	88
XL93-192	LCP86-454	LCP81-010	3156
XL93-194	LCP82-089	LCP81-010	3680
XL93-151	CP89-846	LCP81-010	540
XL93-154	LCP81-010	LCP81-010	7723
XL93-193	CP89-800	LCP81-010	1481
XL93-150	CP90-957	LCP81-010	277

Table 9. Crosses and seed made in 1993 sorted by male parent.

Cross	Female	Male	Seed
XL93-153	L90-178	LCP81-010	1140
XL93-195	L75-056	LCP81-010	3223
XL93-152	CP88-769	LCP81-010	972
XL93-172	L90-178	LCP82-089	996
XL93-165	LCP86-429	LCP82-089	12165
XL93-164	LCP85-384	LCP82-089	10213
XL93-074	CP89-843	LCP82-089	162
XL93-084	LCP81-010	LCP82-089	1978
XL93-043	LCP82-089	LCP82-089	992
XL93-213	LCP85-313	LCP82-089	512
XL93-071	CP85-845	LCP82-089	243
XL93-115	CP89-846	LCP82-089	115
XL93-212	US90-024	LCP82-089	0
XL93-313	CP88-739	LCP82-089	961
XL93-327	LHo83-153	LCP82-089	481
XL93-328	CP70-321	LCP82-089	516
XL93-204	US77-017	LCP82-089	332
XL93-117	CP89-800	LCP82-089	180
XL93-266	LCP86-429	LCP82-089	345
XL93-072	L88-046	LCP82-089	7
XL93-205	L75-056	LCP82-089	3115
XL93-116	LCP86-454	LCP82-089	538
XL93-073	L91-288	LCP82-089	18
XL93-173	L90-191	LCP82-089	2114
XL93-060	CP91-577	LCP82-089	1430
XL93-042	L91-288	LCP82-089	1229
XL93-348	CP89-879	LCP82-089	2205
XL93-059	US90-026	LCP82-089	1595
XL93-277	CP87-657	LCP82-089	749
XL93-258	CP70-321	LCP85-384	330
XL93-136	US90-021	LCP85-384	2468
XL93-201	LHo83-153	LCP85-384	169
XL93-167	CP89-846	LCP85-384	737
XL93-200	LCP82-089	LCP85-384	1856
XL93-134	LCP86-454	LCP85-384	2845
XL93-202	CP88-739	LCP85-384	297
XL93-209	CP89-800	LCP85-384	565
XL93-166	LCP86-454	LCP85-384	2959
XL93-211	CP89-846	LCP85-384	1483
XL93-260	US90-026	LCP85-384	985
XL93-311	CP89-879	LCP85-384	750
XL93-247	US77-017	LCP85-384	910
XL93-210	L90-191	LCP85-384	747
XL93-354	US90-026	LCP85-384	571
XL93-259	LCP85-313	LCP85-384	174
XL93-350	L91-288	LCP85-384	58
XL93-203	CP85-845	LCP85-384	946
XL93-275	LCP87-017	LCP85-384	628
XL93-248	CP91-516	LCP85-384	1023
XL93-276	US90-021	LCP85-384	827
XL93-349	US90-018	LCP85-384	320
XL93-274	L88-046	LCP85-384	179
XL93-137	LCP85-384	LCP85-384	2859
XL93-336	CP88-739	LCP85-384	643
XL93-246	L88-046	LCP85-384	279
XL93-135	US90-024	LCP85-384	351
XL93-312	CP85-845	LCP85-384	3175
XL93-304	CP70-321	LCP85-384	439
XL93-301	US77-017	LCP85-384	1623
XL93-351	CP88-739	LCP86-429	58
XL93-353	LCP86-429	LCP86-429	13
XL93-352	L88-046	LCP86-429	14
XL93-149	LCP86-454	LCP86-454	500
XL93-231	CP85-845	LCP86-454	346
XL93-148	CP89-846	LCP86-454	1788
XL93-147	CP90-957	LCP86-454	819
XL93-230	L90-178	LCP86-454	1330
XL93-249	CP89-846	LCP86-454	794
XL93-070	LCP87-017	LCP87-017	2701
XL93-189	L91-250	LCP87-017	194
XL93-086	LCP87-017	LCP87-017	487
XL93-069	L88-046	LCP87-017	0
XL93-178	LCP85-384	LCP87-017	367
XL93-105	CP89-846	LCP87-017	1248
XL93-075	L75-056	LCP87-017	217
XL93-106	LCP86-429	LCP87-017	367
XL93-188	CP88-739	LCP87-017	493
XL93-176	CP89-800	LCP87-017	76
XL93-177	L90-178	LCP87-017	517
XL93-067	CP85-845	LCP87-017	166
XL93-108	L75-056	LCP87-017	274
XL93-101	LCP86-454	LCP87-017	431
XL93-068	CP89-843	LCP87-017	158
XL93-107	CP91-552	LCP87-017	4130
XL93-319	LCP85-313	LHo92-307	99
XL93-280	LHo92-307	LHo92-307	115
XL93-355	CP89-879	LHo92-307	772
XL93-296	CP85-845	LHo92-307	289
XL93-320	CP89-800	LHo92-307	323
XL93-278	US77-017	LHo92-307	1482
XL93-279	CP79-318	LHo92-307	1925
XL93-356	CP85-845	LHo92-307	600
XL93-267	L88-046	US77-017	210
XL93-268	US77-017	US77-017	152
XL93-146	CP89-846	US90-018	1512
XL93-017	L91-255	US90-018	1833
XL93-145	LCP86-454	US90-018	1299
XL93-066	CP91-505	US90-018	790
XL93-014	CP91-530	US90-018	11
XL93-015	US90-018	US90-018	2920

Table 9. Continue.

Cross	Female	Male	Seed
XL93-337	CP85-845	US90-021	1963
XL93-281	CP79-318	US90-021	4521
XL93-282	US77-017	US90-021	384
XL93-283	US90-021	US90-021	188
XL93-191	CP89-846	US90-027	3836
XL93-022	L91-250	US90-027	884
XL93-023	US90-027	US90-027	372
XL93-049	L91-276	US90-027	992
XL93-174	CP76-331	US90-027	2288
XL93-175	CP91-516	US90-027	940
XL93-021	CP91-557	US90-027	30
XL93-048	CP91-523	US90-027	279
XL93-190	L90-178	US90-027	1969
			====
			364169

SELECTIONS, ADVANCEMENTS, AND ASSIGNMENTS OF THE LOUISIANA, "L", SUGARCANE VARIETY DEVELOPMENT PROGRAM FOR THE YEAR 1993

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In the four years after crosses are made, selected clones of cross progeny are advanced through four stages of selection: seedling to 1st line, 1st line to 2nd line, 2nd line to increase, and increase to nursery (Table 1). The first yield estimates are made in the 2nd line trials, while the first replication trials are at the increase stage. Clones advanced from the increase stage are named with permanent assignment numbers.

In April 1993, 56,309 seedlings from 132 crosses were successfully transplanted to the field. The majority of the seedlings (45,809 from 89 crosses) were scheduled for routine selection. Ten thousand five hundred seedlings, 132 crosses at St. Gabriel and 45 crosses at USDA, Chacahoula were also transplanted into a two replicate cross appraisal test. Since 1991, seedlings have been planted on a rototilled bed irrigated with a modified spray rig. The advantages of this approach compared with the furrow irrigation system, which required seedlings to be transplanted and irrigated within a row furrow similar to the one used in fall planting of sugarcane stalks, are: (1) one man can easily water seedlings as soon as they are transplanted and (2) weed control is more easily achieved.

In the first stage of advancement, stalks from selected stubble-single stool seedlings are used to plant the 1st line trial. The 1991 Crossing Series, which was at this stage in 1993, was the first series in which family selection was imposed prior to single plant selection within the selected families. Family selection was based on replicated cross appraisal test data. Forty-four percent of the 169 families or 75 crosses were eliminated on cross performance alone. This dropped 36.5% or 20,328 of the initial 55,625 seedlings. Work refining the accuracy and use of the progeny test data is continuing. Of the initial 4,850 clones selected, 2,690 or 55.5 % that had Brix value greater than 17% were planted in 1st line trials (Table 1).

As a result of damage caused by Hurricane Andrew in 1992, single stool selection and planting of first line clone trials of the 1990 Crossing Series were not accomplished until November 1992. This resulted in poor stands and heavy weed pressure in the 1993 plant cane first line trials. The resulting loss of first line clones in 1993 (Table 2a) was much greater than in normal years. Cane yield ratings of the check variety plots of CP70-321 were also quite poor (Table 2b). Had the same criteria of selection used among the experimentals been imposed on the checks (rating < 7), 38% of the CP70-321 plots would have been eliminated. The 1440 clones that passed the rating screen in August were checked for the following faults in October: borer, lodged, pith or tube, low stalk number, short stalks, or smut. Pithiness was the most common reason for not advancing a clone (Table 2c). Of the 937 clones that passed the above

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screening, 267 were dropped for low Brix. Thus 670 clones were advanced to the second line trials (tables 1 and 2c).

Selecting clones of the 1989 Crossing Series for advancement from second line trials to the increase stage began with counting stalks and inspecting for smut in each clone. About 25% of the initial 450 clones were eliminated for low stalk number (Table 3). Of those passing this initial screen, pith was again the most prominent reason for dropping clones. The 202 clones advanced to the increase stage of the program were evaluated for sucrose content. Mean estimated cane yield in the first line trial first ratoon crop and the second line trial plant-cane crop for the 1989 Crossing Series is presented in Table 4. This type of sampling is routine in the program.

Of the initial 181 clones in the increase stage of the 1988 Crossing Series, 42 were assigned variety numbers in 1993. A list of the 1993 assignments and a summary of all current data for these assignments is provided in Table 5. Note that data from the heavy soil increase replication were collected after the assignment of permanent numbers.

Table 1. Summary of selections, advancements and assignments made during 1993 by the Louisiana, "L", Sugarcane Variety Development Program personnel.

Crossing series	Crosses	Seedlings surviving trans-planting	Over-wintered	Advanced to			
				1st line	2nd line	Increase	Assigned
year	no.	number of clones					
1988	252	64642	28546	4612	813	181	42†
1989	192	64003	48715	2779	450	202†	
1990	243	55110	48687	3555	670†		
1991	163	55625	49664	2690†			
1992	132	56309†§					

† Work performed in 1993.
§ Includes 10,500 seedlings planted into cross appraisal tests.

Table 2a. Percentage and number of clones, and reasons for dropping clones from the 1990 crossing series plant-cane first line trial in 1993. Initial cutoff used in 1993 was a rating ≤ 6. First line clones undergo three stages of screening.

Clones planted		Over-wintered	Cane Yield Rating†								Subtotal (rating <7)
			2	3	4	5	6	7	8	9	
no.	3555	3514	2	3	71	710	654	781	713	580	1440
%	100	98.8	0.1	0.1	2.0	20.0	18.4	22.0	20.1	16.3	40.5

† Ratings performed August 10, 1993. 1 is most desirable, 9 is most undesirable.

Table 2b. Percentage and rating frequency of the check CP70-321 used in the 1990 crossing series plant-cane first line trial in 1993.

	Cane Yield Rating								Total
	2	3	4	5	6	7	8	9	
no.	0	0	0	25	49	29	15	1	119
%	0	0	0	21.0	41.2	24.4	12.6	0.8	100

Table 2c. Percentage and number of clones, and reasons for dropping of clones in 1990 crossing series plant-cane first line trial - second and third stages of screening in 1993.

Clones passing for rating screen		Clones eliminated because of - Faults†‡								Advanced to 2nd Line
		Borer	Lodged	Pith	Stalk no.	Short	Smut	Tube	Brix	
no.	1440	40	23	327	8	57	55	3	267	670
%†	40.9	1.1	0.6	9.2	0.2	1.6	1.6	0.1	7.5	18.8

† Stage 2 and 3 faults evaluated August 16, 1993.

‡ Percentages are based on the initial number of 1st line clones - 3555.; Some clones had more than one fault listed.

Table 3. Percentage and reasons for dropping clones from the 1989 crossing series plant-cane second line trial in 1993.

Clones in trial		Clones eliminated because of faults							Advanced to increase
		Smut	Stalk no.	Pith	Lodged	Borer	Stalk no.	Stalk wt.	
no.	450	27	114	78	3	19	2	11	202
%	100	6.0	25.3	17.3	0.7	4.2	0.4	2.4	

† Stage 1 and 2 faults evaluated August 10 and August 16, 1993, respectively.

Table 4. Mean yield data of 201 clones of the 1989 crossing series that were advanced to increase stage in 1993.

Stage, population and crop	Obs.	Sucrose yield	Cane yield	Sucrose content	Stalk number	Stalk weight
	no.	lbs/A	tons/A	lbs/ton	no./A	lbs.
1st line, experimentals, first ratoon	201	--	--	258 ± 25	--	1.53 ± 0.32
1st line, CP70-321, first ratoon	34	--	--	283 ± 16	--	1.66 ± 0.32
2nd line, experimentals, plant-cane	201	6577 ± 1546	26.2 ± 6.2	252 ± 21	30509 ± 5687	1.73 ± 0.35
2nd line, CP70-321, plant-cane	8	5433 ± 2206	20.4 ± 7.7	264 ± 12	22622 ± 5552	1.76 ± 0.29
2nd line, LCP 82-089 plant-cane	8	5045 ± 1558	19.0 ± 5.7	265 ± 8	21319 ± 6024	1.78 ± 0.15
Mean - CP70-321	42	--	--	280 ± 17	--	1.68 ± 0.31
Mean - experimentals	402	--	--	255 ± 23	--	1.63 ± 0.35

† 1st line and 2nd line harvested November 10 and November 30, 1993, respectively.

Table 5. Summary of 1993 assignment data†.

Variety	Female	Male	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
			lbs/A	tons/A	lbs/ton	lbs	no./A
CP70-321	CP61-39	CP57-614	5651	24.6	290	2.28	23368
L93-358	CP79-332	CP77-310	6865	29.3	267	2.43	27679
L93-359	CP76-351	CP77-407	5609	30.6	222	1.95	32671
L93-360	LCP85-384	CP80-329	3070	12.3	272	1.07	24503
L93-361	CP80-328	CP70-321	3151	12.2	258	1.34	19965
L93-362	CP79-332	CP72-370	6062	28.0	257	2.13	24503
L93-363	LCP85-313	LCP85-336	7299	32.1	255	2.03	30402
L93-364	LCP85-313	LCP85-336	7347	27.5	282	1.69	34032
L93-365	CP78-304	CP72-2086	5072	24.3	256	2.19	22688
L93-366	LCP85-384	CP80-329	6723	29.5	259	1.65	37888
L93-367	MISC.	MISC.	3750	15.6	270	1.72	28587
L93-368	CP80-328	CP70-321	4309	18.6	262	1.82	26771
L93-369	LCP85-316	CP67-412	4621	19.2	274	1.73	27225
L93-371	LCP85-307	CP84-772	5699	26.0	243	2.33	23822
L93-372	CP75-327	LCP85-336	5970	28.7	250	2.04	32670
L93-373	CP65-357	LCP81-030	5529	25.8	248	2.04	27226
L93-374	CP83-644	LCP82-089	5430	23.9	263	1.46	36754
L93-375	CP79-332	CP84-722	5919	28.7	240	1.72	33578
L93-376	CP75-327	LCP85-336	6175	30.1	251	1.92	35166
L93-377	CP65-357	LCP81-030	4125	22.0	244	1.61	32217
L93-378	LCP85-313	LCP85-336	8873	39.8	260	1.98	41745
L93-379	CP74-383	LCP85-336	3893	18.9	253	1.31	28814
L93-380	MISC.	MISC.	5336	20.2	281	1.62	32443
L93-381	LCP85-384	LCP85-336	3300	12.4	291	1.19	34939
L93-382	LCP81-005	CP74-2013	7160	31.3	270	2.17	28587
L93-385	LCP82-046	LCP81-030	5382	23.1	270	2.29	31082
L93-386	CP79-332	L84-290	5930	27.6	235	1.73	33124
L93-387	CP74-383	LCP85-336	5404	26.4	252	1.95	29040
L93-388	LCP85-384	CP80-329	4207	24.0	239	1.87	29721
L93-389	CP52-068	LCP81-030	6177	29.6	242	1.98	34712
L93-390	CP72-370	LCP82-047	5212	23.2	242	1.83	29267
L93-391	CP79-348	CP80-323	4808	20.7	264	2.12	23822

Variety	Female	Male	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
L93-392	CP79-348	CP80-323	5377	25.2	246	2.13	29948
L93-393	CP80-328	CP70-321	7262	29.7	263	1.63	38569
L93-394	CP79-348	LCP81-030	5667	22.0	286	1.97	33351
L93-395	MISC.	MISC.	7733	30.6	270	2.17	29267
L93-396	CP79-348	LCP81-030	8031	36.9	247	2.48	34939
L93-397	LCP81-030	CP77-310	6366	24.6	273	1.91	27225
L93-398	LCP85-384	CP80-329	6001	29.7	245	1.92	36754
L93-399	L84-218	CP74-383	4167	17.4	276	1.86	28133
L93-400	LCP85-384	CP80-329	5288	33.4	223	1.66	47871
L93-401	CP79-348	LCP85-384	6873	31.2	252	1.95	34486
L93-402	CP75-361	L84-290	6366	28.9	250	1.39	42426
Mean			5576	25.1	271	2.04	29984
$LSD_{0.05}$			3232	13.6	21	0.44	10103

† Assignments data from the 1st clonal, 2nd clonal, light and heavy soil increase tests all performed at the St. Gabriel Research Station. Sucrose yields, cane yields and stalk numbers from the increase tests only. Note that assignments were made prior to the harvest of the heavy soil increase test. Sugarcane in the heavy soil increase test was affected by drought.

1993 LOUISIANA "L" NURSERY VARIETY TRIALS

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Five years after the initial hybridization of parents, clones that have met or exceeded criteria for important characteristics at previous selection stages are assigned permanent numbers by the Louisiana (L) Sugarcane Variety Development Program. These varieties are planted in replicated single row "nursery" tests.

One of the objectives of the nursery stage of the selection program is to identify and select varieties that will perform well across the range of environments a commercial variety will probably encounter in Louisiana. Three tests are normally planted during the year of assignment and three additional tests are planted the year after assignment (Table 1). Poor planting in 1992 associated with Hurricane Andrew resulted in a shortage of seedcane, of the 1993 assignment series. Consequently only two nursery tests were planted with the varieties assigned in 1993.

Nursery trials were planted in single row (six-foot centers), 16 foot long plots using two replications per location in a randomized complete block design. Three commercial check varieties (CP70-321, CP65-357, and LCP82-089) were included in all tests for comparison basis.

Stalk counts were made in August. During the normal harvest season, ten-stalk samples were harvested by hand for stalk weight and juice analysis. The quality of juice extracted by three roller mill was determined by analyzing Brix by refractometer and sucrose by polarization. Cane yield was estimated as the product of stalk weight and stalk number. Sucrose yield was calculated as the product of sucrose content and cane yield.

Analysis of variance was performed for each assigned series, crop and location-soil texture combination. A combined analysis was performed over locations-soil texture for each assignment series. Minimum significant differences (MSD) were calculated by the Waller-Duncan multiple range test (SAS, 1985). Results from Nursery variety trials harvested in 1993 are presented in tables 2-17.

References:
SAS Institute Inc. SAS User's Guide: Statistics, Ver. 5 ed. Cary, NC: SAS Institute Inc., 1985 956pp.

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Table 1. Planting and harvest dates of nursery tests planted or harvested in 1993.

Series	Location[1]	Soil Texture[2]	Planting Date	Harvest Dates			Varieties[3]	
				1991	1992	1993	No. Planted	No. Harvest
1990	Iberia	B.s.c.	10/17/90	11/25	11/17	10/13	68	5
1990	St. G.	S.c.	10/16/90	11/14	12/09	10/07	68	5
1990	St. G.	C.s.l.	10/18/90	ns	10/20	10/08	68	5
1990	Peebles	J.s.l.	09/18/91		11/30	10/13	42	5
1990	Westfield	S.s.c.	10/15/91		12/03	11/17	42	5
1991	Iberia	B.s.c.	10/11/91		12/10	11/19	65	16
1991	St. G.	S.c.	11/15/91		12/01	11/08	65	16
1991	St. G.	C.s.l.	11/16/91		12/01	11/08	65	16
1991	Peebles	Galvez	09/11/92			ns	39	ns
1991	Stoute	B.s.c.	08/20/92			ns	39	ns
1991	Westfield	S.s.c.	10/05/92			11/17	39	16
1992	Iberia	B.s.c.	10/26/92			12/1	67	18
1992	St. G.	S.c.	10/26/92			11/11	70	18
1992	Ardoyne	C.s.l.	09/23/93				41	
1992	Lev.-St.J.	D.s.l.	09/09/93				37	
1992	Glenwood	C.s.l.	10/04/93				41	
1993	Iberia	B.s.c.	10/23/93				45	
1993	St. G.	C.s.l.	10/20/93				45	
1993	Ardoyne	C.s.l.	10/19/93				45	

[1] Iberia- Iberia Research Station, St. G.- St. Gabriel Research Station, Peebles- Peebles Plantation, Westfield- Westfield Plantation, Stoute- D. Stoute Farm, Ardoyne- U.S.D.A. Ardoyne Farm, Lev.-St.J.- Levert- St. John, Glenwood- Glenwood Plantation.

[2] B.s.c.- Baldwin silty clay, C.s.l.- Commerce silt loam, Galvez-Galvez silt loam, J.s.l.- Jeanerette silt loam, S.c.- Sharkey clay, S.s.c.- Sharkey silty clay, D.s.l.- Dundee silt loam.

[3] Number of varieties per replication including three commercial checks. All tests used two replications.

ns not sampled.

Table 2. 1993 second ratoon means of the 1989 "L" series at Peebles Plantation.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	3462	13.9	250	1.42	19512
CP70-321	4634	19.5	239	1.25	31309
CP74-383	4476	17.9	250	1.18	30401
L89-113	6012	25.8	234	1.36	38115
$MSD_{.05}$	915	3.3	NS	NS	4832

Table 3. 1993 second ratoon means of the 1990 "L" series at the Iberia Research Station.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	10254	47.5	217	2.35	40384
CP70-321	9709	41.9	232	2.53	33124
CP74-383	8236	45.1	183	2.09	43107
L90-178	12137	50.3	241	1.93	52182
L90-191	10226	44.5	230	1.90	46963
$MSD_{.05}$	2212	7.2	44	0.23	4264

Table 4. 1993 second ratoon means of the 1990 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	1804	11.2	166	1.15	19512
CP70-321	1626	7.2	231	1.13	12932
CP74-383	1852	9.1	204	1.12	15882
L90-178	2572	12.3	208	0.88	27679
L90-191	3546	18.3	198	1.18	30856
$MSD_{.05}$	1178	3.9	61	NS	5148

Table 5. 1993 second ratoon means of the 1990 "L" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	5946	24.7	241	1.78	27679
CP70-321	4902	18.0	272	1.80	19738
CP74-383	6569	27.9	237	1.48	37889
L90-178	3713	17.8	210	1.52	23595
L90-191	6003	27.9	215	1.73	32217
$MSD_{.05}$	NS	13.9	32	0.31	12125

Table 6. 1993 second ratoon means of the 1990 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	6001	27.8	208	1.76	29191
CP70-321	5412	22.3	245	1.82	21931
CP74-383	5552	27.3	208	1.56	32292
L90-178	6140	26.8	219	1.44	34485
L90-191	6592	30.2	214	1.60	36678
$MSD_{.05}$	NS	NS	NS	0.31	11599

[1]Iberia, St. Gabriel Sharkey clay and Commerce silt loam.

Table 7. 1993 first ratoon means of the 1990 "L" series at Peebles Plantation.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	6644	30.1	222	1.99	30175
CP70-321	6437	27.5	232	1.93	28360
CP74-383	7600	34.3	221	1.84	37208
L90-178	8261	36.0	230	1.51	47644
L90-191	5490	25.1	219	1.40	35846
$MSD_{.05}$	NS	10.5	NS	0.53	5348

Table 8. 1993 first ratoon means of the 1990 "L" series at Westfield Plantation.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	8987	32.7	277	2.11	30175
CP70-321	15868	58.9	268	2.77	41972
CP74-383	8534	37.1	231	2.02	36981
L90-178	9162	31.2	294	1.53	41065
L90-191	8648	35.4	244	1.90	37208
$MSD_{.05}$	NS	NS	21	0.89	NS

Table 9. 1993 first ratoon means of the 1990 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	7815	31.4	249	2.05	30175
CP70-321	11152	43.2	250	2.35	35166
CP74-383	8067	35.7	226	1.93	37094
L90-178	8711	33.6	262	1.52	44354
L90-191	7069	30.2	232	1.65	36527
$MSD_{.05}$	NS	NS	NS	0.68	NS

[1]Peebles and Westfield Plantations.

Table 10. 1993 first ratoon means of the 1991 "L" series at the Iberia Research Station.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number	Fiber
	lbs/A	tons/A	lbs/ton	lbs	no/A	%
CP65-357	4814	22.1	241	1.15	38569	14.3
CP70-321	8797	41.5	211	1.90	44014	----
CP74-383	4912	24.0	224	1.05	46056	12.7
L91-230	4369	18.7	243	0.96	39023	13.4
L91-232	7210	37.2	208	1.60	45602	14.9
L91-250	5619	24.8	248	0.91	54450	13.6
L91-255	5265	20.6	265	1.02	40838	10.1
L91-261	4423	16.2	286	0.92	35620	12.7
L91-264	4041	16.7	250	0.97	35166	14.8
L91-266	5392	21.2	265	0.89	47871	14.0
L91-276	4474	19.2	235	1.02	38115	12.5
L91-281	5558	22.8	254	0.84	54450	13.6
L91-285	4248	20.5	227	1.04	39250	13.6
L91-286	3726	14.9	257	0.66	45375	14.3
L91-288	4978	21.0	246	0.84	50367	14.6
L91-290	3290	14.0	252	0.73	38569	15.7
$MSD_{.05}$	3084	13.0	28	0.55	8429	1.6

Table 11. 1993 first ratoon means of the 1991 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number	Fiber
	lbs/A	tons/A	lbs/ton	lbs	no/A	%
CP65-357	4945	22.0	227	1.25	34485	12.0
CP70-321	5852	20.4	286	1.17	33124	11.2
CP74-383	3372	14.3	238	1.10	26091	11.4
L91-230	6922	29.0	240	1.36	42653	12.1
L91-232	5526	25.5	218	1.30	39250	11.7
L91-250	5149	20.8	249	1.10	37435	11.0
L91-255	7937	28.7	277	1.59	36754	10.5
L91-261	7941	29.4	269	1.33	44241	11.4
L91-264	7863	33.7	226	1.39	47417	12.0
L91-266	7494	29.8	257	1.67	35620	12.1
L91-276	4673	21.7	216	1.09	39023	11.5
L91-281	7347	30.1	246	1.44	42426	11.3
L91-285	4706	24.6	192	1.92	25637	11.1
L91-286	3758	16.9	223	0.91	37888	11.5
L91-288	6347	28.3	224	1.12	51047	12.5
L91-290	5191	21.6	242	1.12	36981	13.4
$MSD_{.05}$	5924	23.8	29	0.47	NS	1.8

Table 12. 1993 first ratoon means of the 1991 "L" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number	Fiber
	lbs/A	tons/A	lbs/ton	lbs	no/A	%
CP65-357	6130	22.3	275	2.02	22234	14.2
CP70-321	6666	23.8	284	1.91	24503	12.1
CP74-383	8915	37.0	242	1.97	37662	11.4
L91-230	7717	30.7	250	1.60	39023	15.2
L91-232	7652	32.7	233	1.72	37662	12.8
L91-250	8923	33.8	264	1.48	45829	13.4
L91-255	10323	36.3	284	2.20	32443	12.9
L91-261	9696	37.3	261	1.94	38569	14.6
L91-264	10278	42.3	242	1.88	44921	13.6
L91-266	13775	53.4	260	2.26	46963	13.5
L91-276	8387	35.6	233	1.99	35846	14.2
L91-281	8626	37.0	234	1.88	39023	14.1
L91-285	8499	35.5	240	2.21	32444	13.5
L91-286	8187	33.0	245	1.34	48779	13.4
L91-288	5320	21.8	245	1.17	36981	13.1
L91-290	11488	41.4	275	1.75	46964	15.4
$MSD_{.05}$	7809	25.6	46	0.71	17855	3.4

Table 13. 1993 first ratoon means of the 1991 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number	Fiber
	lbs/A	tons/A	lbs/ton	lbs	no/A	%
CP65-357	5296	22.1	248	1.47	31763	13.5
CP70-321	7105	28.5	260	1.66	33880	11.7
CP74-383	5733	25.1	234	1.37	36603	11.8
L91-230	6336	26.1	244	1.30	40233	13.5
L91-232	6796	31.8	219	1.54	40838	12.8
L91-250	6752	26.8	255	1.21	44195	12.5
L91-255	7842	28.5	275	1.60	36678	11.1
L91-261	7353	27.6	272	1.39	39476	12.9
L91-264	7394	30.9	239	1.41	42501	13.4
L91-266	8887	34.8	260	1.61	43484	13.2
L91-276	5844	25.5	228	1.37	37661	12.7
L91-281	7177	30.0	244	1.39	45300	13.0
L91-285	5817	26.8	220	1.72	32443	12.7
L91-286	5223	21.6	242	0.97	44014	13.0
L91-288	5548	23.7	238	1.04	46132	13.4
L91-290	6656	25.6	256	1.20	40838	14.8
$MSD_{.05}$	4353	NS	30	0.50	13870	1.5

[1]Iberia, St. Gabriel Sharkey clay and Commerce silt loam.

Table 14. 1993 plant cane means of the 1991 "L" series at Westfield Plantation.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP70-321	10414	40.0	261	2.33	34485
CP74-383	9007	37.2	245	2.58	28587
LCP82-089	10555	38.6	275	2.38	32443
L91-230	11507	48.6	237	2.47	39250
L91-232	11837	53.2	223	2.55	41972
L91-250	10819	40.5	268	2.16	37662
L91-255	15542	60.0	260	2.71	44241
L91-261	10574	38.0	279	1.85	41291
L91-264	9348	37.8	250	2.21	34259
L91-266	11586	42.6	273	2.47	34712
L91-276	10089	39.2	258	2.21	35393
L91-281	10605	41.3	257	2.37	34712
L91-285	9296	39.9	235	2.77	28360
L91-286	5611	22.1	250	1.65	27452
L91-288	9574	37.3	257	1.87	40157
L91-290	10110	39.9	254	2.13	37435
$MSD_{.05}$	4541	20.5	30	0.39	18324

Table 15. 1993 plant cane means of the 1992 "L" series at the Iberia Research Station.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP70-321	7483	26.9	278	2.41	22007
CP74-383	8497	32.9	259	2.66	24730
LCP82-089	7168	26.3	275	2.49	20873
L92-291	6564	25.5	257	2.17	23595
L92-292	6256	23.7	264	2.16	21553
L92-293	5907	24.9	238	2.18	22915
L92-295	6454	26.5	246	2.38	22234
L92-299	3691	14.7	253	2.16	13613
L92-301	6780	24.3	280	2.28	21327
L92-303	7537	31.1	242	2.50	24957
L92-304	8287	31.6	263	2.58	24503
L92-307	9281	34.4	270	3.13	22007
L92-309	6793	24.8	274	2.67	18604
L92-310	8115	32.0	254	2.51	25410
L92-311	7082	30.5	234	1.82	33351
L92-312	6386	23.8	269	2.12	22461
L92-313	6520	25.5	255	1.75	29267
L92-314	8634	33.2	262	2.55	25864
L92-315	5093	20.4	253	1.70	23822
L92-317	5302	24.1	224	2.52	18831
L92-318	6393	24.1	267	2.14	22461
L92-319	8827	32.4	273	2.62	24503
L92-321	9601	36.7	262	3.27	22461
L92-322	8160	28.4	287	2.67	21327
L92-323	6284	22.8	277	1.79	25411
L92-328	5860	23.2	253	2.22	20873
L92-329	5403	22.5	241	2.25	19966
L92-333	5438	21.0	259	2.33	18150
L92-334	6144	26.1	236	2.94	17923
L92-335	6185	25.3	245	1.98	25637
L92-337	7577	28.5	266	1.93	29721
L92-342	5093	20.7	247	2.28	18150
L92-349	6324	24.0	263	1.61	29721
L92-351	6612	27.9	238	2.47	22461
L92-353	6783	30.2	225	2.00	30402
L92-355	10739	37.6	285	2.63	28360
L92-356	5385	21.5	253	1.93	21781
$MSD_{.05}$	4273	18.3	20	.43	9553

Table 16. 1993 plant cane means of the 1992 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP70-321	5499	21.7	255	1.40	31082
CP74-383	6144	28.1	221	1.98	28133
LCP82-089	4042	15.1	268	1.30	23142
L92-291	5703	24.4	234	1.36	35847
L92-292	6149	25.3	243	1.42	35620
L92-293	6467	29.1	225	1.79	32443
L92-295	7857	35.7	221	2.03	35393
L92-299	6348	26.9	237	1.61	33578
L92-301	3797	15.2	246	1.34	22461
L92-303	6896	32.3	214	1.58	41065
L92-304	6423	28.9	214	1.67	34485
L92-307	4746	19.9	239	1.52	26772
L92-309	5813	24.0	243	1.90	25184
L92-310	6727	26.1	256	1.88	27452
L92-311	5316	22.7	235	1.14	39704
L92-312	7078	27.6	258	1.55	35620
L92-313	7018	29.5	238	1.36	43560
L92-314	4568	20.1	226	1.39	28587
L92-315	3459	15.4	224	0.97	31536
L92-317	4189	25.4	164	1.89	26772
L92-318	3434	20.4	169	1.56	26545
L92-319	8358	33.1	252	1.99	33351
L92-321	5295	21.3	250	1.93	22234
L92-322	8524	29.4	290	1.81	32444
L92-323	6168	26.9	228	1.63	32670
L92-328	4912	20.9	235	1.14	36754
L92-329	3902	18.1	214	1.39	25864
L92-333	5739	23.4	246	1.46	32217
L92-334	7278	34.2	207	2.02	33124
L92-335	4132	17.8	232	1.24	28813
L92-337	4908	22.9	215	1.37	33351
L92-342	6253	25.2	248	1.44	34939
L92-349	9136	35.3	256	1.24	56719
L92-351	4694	28.0	169	2.16	26771
L92-353	5525	25.0	221	1.21	41291
L92-355	6076	23.4	262	1.34	34939
L92-356	3715	15.7	237	0.94	33578
$MSD_{.05}$	4134	13.7	32	0.53	9876

Table 17. 1993 plant cane means of the 1992 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP70-321	6491	24.3	266	1.90	26545
CP74-383	7321	30.5	240	2.32	26431
LCP82-089	5605	20.7	271	1.89	22007
L92-291	6133	25.0	245	1.76	29721
L92-292	6202	24.5	253	1.79	28586
L92-293	6187	27.0	231	1.99	27679
L92-295	7155	31.1	233	2.20	28813
L92-299	5020	20.8	245	1.88	23595
L92-301	5288	19.7	263	1.81	21894
L92-303	7217	31.7	228	2.04	33011
L92-304	7355	30.3	239	2.12	29494
L92-307	7014	27.1	254	2.32	24389
L92-309	6303	24.4	258	2.28	21894
L92-310	7421	29.0	255	2.19	26431
L92-311	6199	26.6	234	1.48	36527
L92-312	6732	25.7	263	1.84	29040
L92-313	6769	27.5	247	1.55	36414
L92-314	6601	26.6	244	1.97	27225
L92-315	4276	17.9	238	1.33	27679
L92-317	4746	24.7	194	2.20	22801
L92-318	4914	22.2	218	1.85	24503
L92-319	8592	32.7	262	2.31	28927
L92-321	7448	29.0	256	2.60	22347
L92-322	8342	28.9	288	2.24	26885
L92-323	6226	24.8	253	1.71	29040
L92-328	5386	22.0	244	1.68	28813
L92-329	4652	20.3	228	1.82	22915
L92-333	5588	22.2	252	1.89	25183
L92-334	6711	30.1	222	2.48	25524
L92-335	5159	21.6	238	1.61	27225
L92-337	6242	25.7	240	1.65	31536
L92-342	5673	22.9	247	1.86	26544
L92-349	7730	29.7	259	1.43	43220
L92-351	5653	27.9	203	2.31	24616
L92-353	6154	27.6	223	1.60	35846
L92-355	8407	30.5	273	1.98	31649
L92-356	4550	18.6	245	1.43	27679
$MSD_{.05}$	4264	17.2	33	0.46	10198

[1]Iberia and St. Gabriel Sharkey clay.

1993 LOUISIANA "L" INFIELD VARIETY TRIALS

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The infield variety trials of the Louisiana (L) Sugarcane Variety Development Program have traditionally been planted from the year after number assignment through the year of introduction to outfield test locations for seed increase. These trials are the first machine harvested tests in the program. The purpose of the trials is to estimate yields on a larger plot basis than used by earlier stages in the selection program and to initiate screening of experimental clones for suitability to mechanical harvest.

The growth of the 1993 sugarcane crop at St. Gabriel was affected by the March 12-13 freeze and below normal rainfall during the growing season. Some varieties and tests were more adversely affected than others. The sugarcane on the light soil, which is nearer the Mississippi River, was not as adversely affected as the sugarcane on the heavy soil.

Normal cultural practices were used in 1993. Sinbar (1/2 lb./A terbacil) + Atrazine (2 qt./A) was applied to tests on Sharkey clay and Sencor 4L (2 qt./A;41% AI) + Atrazine (2 qt./A) was applied to tests on Commerce silt loam after planting in the fall. In early February, 2-4,D (1 qt./A;46.88% AI) + Atrazine (2 qt./A) was applied to all plant-cane and ratoon trials. During the third week of April, Sencor 4L (2 qt.;41% AI) + 2-4,D (1 qt./A; 46.88% AI) was applied after off-barring. Asulox (4.0 pts./A) was applied once in early April and again, where needed, in May. Fields were fertilized with (120 lbs. N; 32% liquid N) in April. Sugarcane borer (*Diatrea saccharalis F*) populations were monitored in June, July, and August. Borer infestations in the cane on lighter soils reached economic thresholds during July and were treated with one helicopter application of Guthion (0.75 lbs./A) on August 1, 1993.

At Ardoyne Farm, normal cultural practices were used in 1993. In early April, Karmex (1 lb./acre) and Weedmaster (1 qt./acre) were applied. Tests were fertilized on April 24, 1993 at a rate of 100 lbs. N, 34 lbs. P, and 67 lbs. K. Infield tests were laybyed during the first week of June and Atrazine (1.5 qt./acre plus Prowl 3.3 EC (2 qt./acre) were applied.

The infield variety trials were planted in Sharkey clay (very fine, montmorillontic, nonacid, thermic, typic hydralquent) and Commerce silt loam (fine-silty, mixed, nonacid, thermic, aeric fluvaquent) soils on the St. Gabriel Research Station and in a Commerce silt loam at the USDA-ARS Ardoyne Farm near Chacahoula, LA. For each assignment series, infield tests have traditionally been planted for three years. In the past, the LAES and USDA would

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plant their experimental varieties in infield trials on their respective farms in the first year after assignment. The agencies would also exchange the same varieties to plant seedcane plots at the other agency's farm. In the following two years, varieties from both agencies were planted together in tests at each agency's farm. Due to the increased numbers of off-station nursery tests, the program was able to advance the majority of the 1991 series varieties to the outfield one year sooner than previously practiced. Starting in 1993, varieties were planted in only one infield test at St. Gabriel prior to introduction to the outfield tests. Starting in 1992, the last replanting of the infield tests was discontinued and in exchange the introductory plots of the outfield tests were planted in a standardized fashion to enable comparative yield estimates to be made in future years.

The 91-92 L & CP series were planted in one trial on September 9, 1993 (Table 1). Randomized complete block design with plots 16 feet long by three rows wide on six-foot centers were used in trial. Three commercial check varieties, CP65-357, CP70-321, and LCP82-089, were included in the test.

From October 21 through November 22, 1993 (Table 1), infield trials were mechanically cut and unburned plots weighed with a tractor mounted hydraulic weigh rig. No adjustments were made for trash weight. Ten-stalk samples, stripped of leaves, were used to estimate stalk weight and obtain a juice analysis. Juice quality was determined in usual manner. Sucrose yield was estimated as the product of cane yield and sucrose content.

Analysis of variance was performed for each crop and assignment series over and by soil type when appropriate. Minimum significant differences (MSD) were calculated by the Waller-Duncan multiple range test (SAS, 1985).

References:

SAS Institute Inc. SAS User's Guide: Statistics, Ver. 5 ed. Cary, NC: SAS Institute Inc., 1985 956pp.

Table 1. Planting and harvest dates of infield tests[1].

Assignment Series	Reps	Soil[2] Texture	Planting Dates	Harvest Dates 1993	1992	1991	Varieties[3] No. Planted	No. Harvest
1987 L & CP	2	C.s.l.*	08/21/90	10/12	10/29	11/19	23	4
1987 L & CP	2	C.s.l.	08/21/90	10/22	11/23	11/18	24	4
1987 L & CP	2	S.c.	08/30/90	10/21	11/23	11/18	24	4
1988 L & CP	2	C.s.l.*	08/31/90	10/14	10/28	11/21	42	7
1988 L & CP	2	C.s.l.	08/22/90	10/22	11/23	11/18	41	7
1988 L & CP	2	S.c.	09/26/90	10/21	11/20	11/14	41	7
1989 L	2	C.s.l.	09/28/90	10/26	11/23	11/20	49	4
1989 L	2	S.c.	09/25/90	10/21	11/20	11/21	49	4
1988 L & CP	2	C.s.l.*	10/01/91	10/14	11/18		16	7
1988 L & CP	2	C.s.l.	09/25/91	11/01	12/04		16	7
1988 L & CP	2	S.c.	10/01/91	11/02	11/30		15	7
1989 L & CP	2	C.s.l.*	09/19/91	11/01	12/01		56	10
1989 L & CP	2	C.s.l.	09/26/91	11/01	12/04		53	10
1989 L	2	S.c.	10/07/91	11/01	11/31		27	4
1990 L	2	C.s.l.	10/04/91	11/01	12/04		42	5
1990 L	2	S.c.	09/27/91	11/03	11/30		42	5
1990 L & CP	2	C.s.l.*	09/15/92	11/18			42	14
1990 L & CP	2	C.s.l.	09/08/92	11/22			41	13
1990 L & CP	2	S.c.	09/09/92	11/16			41	13
1991 L	2	S.c.	09/30/92	11/16			39	16
1992 L	2	S.c.	09/07/93				41	

[1] Tests conducted at the St. Gabriel Research Station and the U.S.D.A. Ardoyne Farm.
[2] C.s.l.-Commerce silt loam, S.c.-Sharkey clay, C.s.l. *- Ardoyne Farm Commerce silt loam.
[3] Number of varieties per replication including 3 commercial checks.

Table 2. 1993 second ratoon means of the 1987 "L" series at Ardoyne Farm.

Variety	Sucrose yield	Cane yield	Sucrose content	Fiber	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	%	lbs	no/A
CP65-357	6044	25.6	236	16.6	1.72	29876
CP70-321	5666	30.3	187	--	1.65	36829
CP74-383	5492	26.8	205	--	1.63	32915
LCP87-017	6371	29.7	214	15.7	1.72	34595
$MSD_{.05}$	872	2.9	13	NS	NS	3907

Table 3. 1993 second ratoon means of the 1987 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	2720	12.8	213	1.35	18923
CP70-321	3833	17.8	217	1.35	26297
CP74-383	3507	16.0	219	1.25	25654
LCP87-017	5441	27.2	201	1.70	31941
$MSD_{.05}$	1192	5.8	15	0.10	9300

Table 4. 1993 second ratoon means of the 1987 "L" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	5958	24.6	242	2.05	24086
CP70-321	8560	29.5	291	2.10	27968
CP74-383	8050	31.8	253	2.05	31197
LCP87-017	8838	31.8	278	1.90	33545
$MSD_{.05}$	2679	NS	26	NS	8660

Table 5. 1993 second ratoon means for the 1987 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	4907	21.0	231	1.71	24295
CP70-321	6020	25.9	232	1.70	30365
CP74-383	5683	24.8	226	1.64	29922
LCP87-017	6883	29.6	231	1.77	33360
$MSD_{.05}$	1643	6.4	NS	NS	4818

[1] Ardoyne Farm, St. Gabriel Sharkey clay and Commerce silt loam.

Table 6. 1993 second ratoon means of the 1988 "L" & "CP" series at Ardoyne Farm.

Variety	Sucrose yield	Cane yield	Sucrose content	Fiber	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	%	lbs	no/A
CP65-357	6572	26.1	252	14.1	1.79	29256
CP70-321	5695	26.8	213	--	1.70	31602
CP74-383	5868	29.0	202	--	2.01	28888
L88-046	5974	24.9	240	12.6	1.60	31210
L88-063	5405	27.3	198	11.4	1.45	37661
CP88-739	7750	28.2	276	13.4	1.86	30393
CP88-769	6064	26.3	231	13.8	1.80	29339
$MSD_{.05}$	1012	2.8	45	0.9	0.29	5643

Table 7. 1993 second ratoon means of the 1988 "L" & "CP" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	4055	20.2	201	1.50	26867
CP70-321	4105	17.6	232	1.45	24405
CP74-383	3674	17.4	211	1.40	25500
L88-046	5719	24.0	238	1.30	36846
L88-063	4698	23.5	199	1.25	37443
CP88-739	7506	27.9	269	1.55	36034
CP88-769	5326	21.8	244	1.35	32346
$MSD_{.05}$	2024	6.6	31	0.34	12431

Table 8. 1993 second ratoon means of the 1988 "L" & "CP" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	5405	22.9	235	2.20	20928
CP70-321	9603	33.7	285	2.25	29919
CP74-383	7226	29.5	245	2.00	29461
L88-046	8693	32.4	268	1.60	40500
L88-063	9843	38.9	253	1.80	43223
CP88-739	10380	36.1	288	1.95	36998
CP88-769	9309	35.9	260	1.95	37088
$MSD_{.05}$	1477	5.2	23	0.46	5869

Table 9. 1993 second ratoon means of the 1988 "L" & "CP" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	5344	23.1	230	1.83	25683
CP70-321	6467	26.0	244	1.80	28642
CP74-383	5589	25.3	220	1.80	27950
L88-046	6795	27.1	249	1.50	36185
L88-063	6649	29.9	217	1.50	39442
CP88-739	8545	30.7	277	1.79	34475
CP88-769	6899	28.0	245	1.70	32924
$MSD_{.05}$	2087	7.4	31	0.25	6754

[1]Ardoyne Farm, St. Gabriel Sharkey clay and Commerce silt loam.

Table 10. 1993 second ratoon means of the 1989 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	2960	16.8	174	1.60	20619
CP70-321	3552	16.1	220	1.25	25416
CP74-383	3097	14.9	207	1.40	21057
LCP89-113	3597	19.6	184	1.35	29284
$MSD_{.05}$	NS	NS	7	0.16	NS

Table 11. 1993 second ratoon means of the 1989 "L" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	6091	24.5	249	2.05	23853
CP70-321	7955	27.1	294	1.85	29441
CP74-383	8354	33.0	253	1.95	33770
LCP89-113	7044	27.2	261	1.75	31199
$MSD_{.05}$	NS	NS	16	NS	NS

Table 12. 1993 second ratoon means of the 1989 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	4526	20.6	212	1.83	22236
CP70-321	5753	21.6	257	1.55	27428
CP74-383	5725	24.0	230	1.68	27413
L89-113	5320	23.4	222	1.55	30241
$MSD_{.05}$	NS	NS	29	0.18	NS

[1]St. Gabriel Sharkey clay and Commerce silt loam.

Table 13. 1993 first ratoon means of the 1988 "L" & "CP" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	4678	17.8	261	1.35	26341
CP70-321	6897	21.4	323	1.55	27740
CP74-383	6237	23.5	264	1.60	29255
L88-046	6187	23.0	269	1.10	41818
L88-063	6421	25.0	258	1.40	35643
CP88-739	7502	24.4	308	1.65	29596
CP88-769	4691	16.5	284	1.30	25385
$MSD_{.05}$	2456	8.3	15	0.36	9404

Table 14. 1993 first ratoon means of the 1988 "L" & "CP" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	6398	24.2	265	2.20	22292
CP70-321	9525	30.6	312	2.50	24485
CP74-383	7439	28.5	261	2.05	27776
L88-046	7535	26.6	284	1.80	29588
L88-063	8947	32.5	275	2.00	32778
CP88-739	8581	29.1	295	2.35	24696
CP88-769	8511	31.0	275	2.05	30274
$MSD_{.05}$	1186	3.9	16	0.55	9579

Table 15. 1993 first ratoon means of the 1988 "L" & "CP" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	5538	21.0	263	1.78	24316
CP70-321	8211	26.0	317	2.03	26112
CP74-383	6838	26.0	263	1.83	28515
L88-046	6861	24.8	276	1.45	35703
L88-063	7684	28.7	266	1.70	34211
CP88-739	8041	26.7	302	2.00	27146
CP88-769	6601	23.7	279	1.68	27830
$MSD_{.05}$	1885	7.3	22	0.30	9727

[1]St. Gabriel Sharkey clay and Commerce silt loam.

Table 16. 1993 first ratoon means of the 1989 "L" & "CP" series at Ardoyne Farm.

Variety	Sucrose yield	Cane yield	Sucrose content	Fiber	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	%	lbs	no/A
CP65-357	8878	30.3	293	13.5	2.09	29239
CP70-321	7911	31.6	251	--	2.04	31041
CP74-383	7639	30.5	251	--	2.27	26946
L89-113	7266	30.2	241	14.9	2.14	28234
CP89-843	9449	35.1	269	11.6	2.02	34947
CP89-846	10152	34.8	292	14.8	1.86	37925
CP89-884	8682	32.4	269	12.8	1.86	34928
CP89-888	8361	31.5	265	10.6	1.99	31738
CP89-889	8402	31.5	267	13.7	2.09	30190
$MSD_{.05}$	1627	NS	30	1.8	0.29	10911

Table 17. 1993 first ratoon means of the 1989 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	5029	19.6	254	1.65	24345
CP70-321	4585	16.1	284	1.15	27854
CP74-383	5381	19.7	274	1.50	26179
L89-113	6137	22.7	271	1.45	31238
$MSD_{.05}$	1312	3.2	NS	NS	NS

Table 18. 1993 first ratoon means of the 1989 "L" & "CP" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	4606	20.2	228	2.00	20346
CP70-321	6580	22.1	298	1.95	22595
CP74-383	7116	28.5	250	2.00	28692
L89-113	6994	26.3	263	1.85	28161
CP89-843	8526	34.1	250	1.90	35843
CP89-846	11515	37.8	305	1.85	41400
CP89-884	10135	39.2	259	1.95	40227
CP89-888	7486	28.0	267	1.85	30287
CP89-889	9666	34.2	283	2.10	32572
$MSD_{.05}$	3191	11.2	20	0.31	14805

Table 19. 1993 first ratoon means of the 1989 "L" & "CP" series across loacations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	6742	25.3	261	2.04	24793
CP70-321	7246	26.8	274	1.99	26818
CP74-383	7377	29.5	250	2.13	27819
L89-113	7130	28.2	252	2.00	28198
CP89-843	8987	34.6	260	1.96	35395
CP89-846	10833	36.3	298	1.85	39663
CP89-884	9409	35.8	264	1.90	37577
CP89-888	7923	29.8	266	1.92	31012
CP89-889	9034	32.8	275	2.09	31381
$MSD_{.05}$	3457	11.0	NS	0.24	8901

[1]Ardoyne Farm and St. Gabriel Commerce silt loam.

Table 20. 1993 first ratoon means of the 1989 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	6171	23.4	258	1.91	24643
CP70-321	6359	23.2	278	1.71	27163
CP74-383	6712	26.2	258	1.92	27272
L89-113	6799	26.4	258	1.81	29211
$MSD_{.05}$	NS	NS	NS	NS	NS

[1]Ardoyne Farm, St. Gabriel Sharkey clay and Commerce silt loam.

Table 21. 1993 first ratoon means of the 1990 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	4641	17.8	263	1.60	21977
CP70-321	5210	16.9	306	1.45	23217
CP74-383	5838	20.7	282	2.10	19840
L90-178	8196	26.0	315	1.45	35857
L90-191	7278	27.6	263	1.70	32389
$MSD_{.05}$	3188	10.5	42	0.68	5024

Table 22. 1993 first ratoon means of the 1990 "L" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	7558	29.3	260	2.05	28703
CP70-321	5908	20.5	288	2.00	20501
CP74-383	6886	25.8	267	2.05	25390
L90-178	5833	20.7	283	1.75	23415
L90-191	6994	27.7	255	2.00	27552
$MSD_{.05}$	NS	NS	38	NS	NS

Table 23. 1993 first ratoon means of the 1990 "L" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	6100	23.5	261	1.83	25340
CP70-321	5559	18.7	297	1.73	21859
CP74-383	6362	23.2	275	2.08	22615
L90-178	7015	23.3	299	1.60	29636
L90-191	7136	27.6	259	1.85	29970
$MSD_{.05}$	NS	NS	23	0.46	NS

[1]St. Gabriel Sharkey clay and Commerce silt loam.

Table 24. 1993 plant cane means of the 1990 "L" & "CP" series at Ardoyne Farm.

Variety	Sucrose yield	Cane yield	Sucrose content	Fiber	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	%	lbs	no/A
CP65-357	9372	32.7	287	13.8	2.13	30654
CP70-321	7519	32.3	233	--	2.47	26365
CP72-370	9475	31.3	302	--	2.14	29231
CP74-383	9138	35.0	261	--	2.11	33299
LCP82-089	8813	31.7	279	--	2.04	31318
L90-178	8606	30.0	287	12.9	2.00	30130
L90-191	6724	27.0	249	13.50	1.88	29004
CP90-923	10265	34.3	300	13.0	1.73	39596
CP90-935	9577	37.9	253	14.5	2.13	35569
CP90-941	10334	35.8	289	12.4	2.51	28498
CP90-955	9376	32.4	290	17.0	1.80	35947
CP90-957	10155	31.9	319	12.7	2.03	31498
CP90-963	9171	31.4	292	14.1	2.32	27171
CP90-977	7909	27.8	285	15.0	2.15	25898
$MSD_{.05}$	1720	5.3	22	1.9	0.35	7839

Table 25. 1993 plant cane means of the 1990 "L" & "CP" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP70-321	6082	22.9	267	1.80	25257
CP74-383	4982	20.6	242	1.90	21681
LCP82-089	5752	21.0	274	1.80	23263
L90-178	7006	28.7	245	1.40	41000
L90-191	5096	22.9	223	1.45	31552
CP90-923	5926	25.2	235	1.70	29778
CP90-935	4898	19.9	247	1.10	37932
CP90-936	7354	27.7	266	1.80	30783
CP90-941	4556	19.2	238	1.95	19663
CP90-955	6698	23.8	283	1.60	29750
CP90-957	6540	23.7	276	1.50	31600
CP90-963	6403	26.4	243	1.85	28518
CP90-977	4684	18.6	251	1.60	23397
$MSD_{.05}$	1822	8.6	20	0.36	1344

Table 26. 1993 plant cane means of the 1990 "L" & "CP" series at the St. Gabriel Research Station on a Commerce silt loam.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP70-321	10320	36.1	287	2.85	25426
CP74-383	8924	34.6	258	2.90	23874
LCP82-089	8416	31.2	270	2.75	22735
L90-178	8426	31.1	271	2.30	27044
L90-191	7869	32.2	244	2.50	25766
CP90-923	9281	36.9	253	1.90	38434
CP90-935	11020	39.0	282	2.75	28430
CP90-936	10576	38.1	278	2.60	29308
CP90-941	10490	39.8	264	3.10	25843
CP90-955	10357	39.4	262	2.30	34697
CP90-957	9828	33.7	292	2.50	26988
CP90-963	11190	40.7	276	3.00	27687
CP90-977	8879	33.6	264	2.35	28600
$MSD_{.05}$	3493	14.9	23	0.48	14342

Table 27. 1993 plant cane means of the 1990 "L" & "CP" series across locations[1].

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP65-357	9372	32.7	287	2.13	30654
CP70-321	7973	30.4	262	2.37	25683
CP72-370	9475	31.3	302	2.14	29231
CP74-383	7681	30.0	254	2.30	26284
LCP82-089	7660	28.0	274	2.20	25772
L90-178	8013	29.9	267	1.90	32725
L90-191	6563	27.4	239	1.94	28774
CP90-923	8491	32.1	263	1.78	35936
CP90-935	8498	32.3	261	1.99	33977
CP90-936	8965	32.9	272	2.20	30046
CP90-941	8460	31.6	264	2.52	24668
CP90-955	8810	31.9	278	1.90	33465
CP90-957	8841	29.7	296	2.01	30029
CP90-963	8921	32.8	270	2.39	27792
CP90-977	7157	26.7	267	2.03	25965
$MSD_{.05}$	2262	8.9	43	0.40	9822

[1]Ardoyne Farm, St. Gabriel Sharkey clay and Commerce silt loam.

Table 28. 1993 plant cane means of the 1991 "L" series at the St. Gabriel Research Station on a Sharkey clay.

Variety	Sucrose yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	lbs/A	tons/A	lbs/ton	lbs	no/A
CP70-321	5315	19.7	271	1.55	25371
CP74-383	5508	22.0	252	1.80	24335
LCP82-089	3665	13.3	275	1.45	18148
L91-230	5111	19.5	262	1.20	32417
L91-232	5250	21.5	245	1.75	24540
L91-250	5851	23.1	253	1.25	37026
L91-255	3727	14.7	252	1.50	19206
L91-261	6255	24.3	259	1.40	34714
L91-264	5623	23.1	244	1.40	33154
L91-266	7532	28.5	265	1.70	33471
L91-276	3848	16.3	236	1.30	25077
L91-281	6862	27.6	249	1.60	34438
L91-285	7050	31.5	224	2.40	26292
L91-286	4876	20.5	238	1.15	35447
L91-288	3111	11.6	270	1.25	18799
L91-290	5888	21.4	276	1.30	33227
$MSD_{.05}$	1767	6.8	33	0.21	8978

1993 OUTFIELD VARIETY TRIALS[1]

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The purpose of the outfield variety trials is to test and identify experimental varieties for potential commercial production. These trials are cooperatively conducted at 13 commercial locations throughout the Louisiana sugarcane belt by the Louisiana Agricultural Experiment Station, the United States Department of Agriculture - Agricultural Research Service and the American Sugar Cane League.

The criteria for a successful variety requires good performance with regard to yield and harvestability across locations, crops, and years relative to commercial varietal responses. Accurate varietal evaluation requires overall yield performance information in addition to close scrutiny of performance under adverse harvest conditions. The objective of this report is to provide overall and specific location yield data by crop for 1993 outfield tests. Also include are two and three yield analyses for appropriate test varieties.

A randomized complete block design with three replications was used at each location. Plots were three rows wide (6-foot centers) and 32 feet long with 5-foot gaps between plot ends. All trials were harvested mechanically, separated by hand, and then weighed with a tractor-mounted hydraulic weigh rig. A 15-stalk sample was taken from each plot and sent to the USDA sucrose lab at the Ardoyne Farm for juice analysis.

Cane yield for each plot was estimated by plot weight. Plots are unburned prior to weighing, so plot weights are reduced by 14% to adjust for leaf-trash weight. All calculations for stalk number per acre and cane yield assumed 36-foot long plots. These two adjustments for plot length and trash weight adjusted downward cane yields, sucrose yields, and stalk number estimates by 26%.

Interpreting one-year yield data can be misleading since performance is bias by genotype by year interactions. Across location means can likewise be misleading since a variety, experimental or commercial, may not consistently perform at all locations, and this inconsistency

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[1] The data for this report was obtained through a cooperative effort of personnel from the Louisiana Agricultural Experiment Station - LSUAC, USDA - Agricultural Research Service, Sugarcane Research Unit, and the American Sugar Cane League in accordance to the provisions of the "Three-way Agreement of 1978." The testing program would not be possible without the full cooperation of the growers at each outfield location.

This project was partially funded by the American Sugar Cane League.

may not be clearly indicated in the overall mean. Multiyear and location testing attempts to solve these problems. A primary goal of the yield trials is to identify varieties that reliably produce high yields and are suitable for mechanical harvesting in the Louisiana sugarcane growing region.

A simple statistic has been included to aid in interpreting a variety's performance relative to other varieties in the test. This statistic is the percentage of the test locations a variety was not significantly (NS) different from the best yielding variety at a specific location. Although the best yielding variety at a location may vary, the "percent best" statistic indicates the percent of the tests a variety was in the best yield group. A variety with a 80% NS from best value was in the highest yielding group in 80% of the tests. This statistic intrinsically places more value on more precise tests and helps the reader avoid making incorrect interpretations of the results due to minor differences in mean values. The statistic also provides a better understanding of varietal yield stability across locations than does the overall mean.

Analysis of variance was performed for each crop and location combination. A combined analysis was performed over locations within each crop. Minimum significant differences (MSD) were calculated by the Waller-Duncan multiple range test (SAS, 1985).

Nineteen experimental varieties were introduced to the outfield locations for seed increase in 1993 (Table 1). Outfield personnel planted 13 experimental and eight commercial varieties at 10 outfield locations in 1993. Thirteen commercial outfield locations were used in 1993. Researchers planted 10 tests and harvested 10 plant-cane, 12 first ratoon, and 9 second ratoon tests.

Varietal yields are reported by crops and trait with overall means and individual location data in the same table (tables 3-17). Combined analysis among 1991 through 1993 plant-cane crops (Table 18), among the 1991 and 1992 first ratoon years (Table 19), and among 1991 and 1992 plant-cane crops (Table 21) are included to aid evaluation of the most advanced experimental varieties, LCP86-454 and LCP87-017.

The harvestability of a sugarcane variety in Louisiana is affected by the erectness and the brittleness of the variety in interaction with the conditions under which it was grown and harvested (weather, row profile, type and condition of the harvester, and skill of the harvester operator). The harvestability of experimental varieties can be observed under a wide range of conditions in the outfield stage of the variety testing program and is an important function of the tests.

Harvestability is subjectively evaluated by documenting the condition of the test field at the time of harvest. As the test field is cut, the outfield agronomists note the erectness of each variety for which yield data will be taken. The heap row is then subjectively rated for scrappiness or the amount of cane left in the plot. The scrappiness rating is summarized in tables 22 through 25 for the three crops harvested in 1993.

References:

SAS Institute Inc. 1985. SAS user's guide:basics, version 5 ed. SAS Institute, Cary H.C.

Table 1. Varieties planted in the outfield in 1993.

Commercial Varieties	Experimental Varieties		Varieties Introduced to the Outfield	
CP65-357	LCP86-454	CP89-843	L90-191	L91-250
CP70-321	LCP87-017	CP89-846	CP90-923	L91-261
CP72-370	L88-046	Ho89-884	CP90-935	L91-264
CP74-383	L88-063	Ho89-888	CP90-941	L91-281
LCP82-089	CP88-739	Ho89-889	CP90-955	L91-286
LHo83-153	CP88-769		CP90-957	L91-288
LCP85-384	L89-113		CP90-963	L91-290
HoCP85-845	CP89-821		CP90-977	CP91-523
			L91-230	CP91-552
			L91-232	

Table 2. Plant-cane, first ratoon, and second ratoon harvest and planting dates for all outfield locations harvested in 1993.

Location	Plant-cane			First ratoon		Second ratoon	
	1993 Plant Date	1993 Harvest Date	1992 Plant Date	1993 Harvest Date	1991 Plant Date	1993 Harvest Date	1990 Plant Date
Allain	10/05	11/30	10/07	10/26	09/05	10/26	09/05
Bon Secour	09/30	12/03	10/08	11/03	10/02	10/19	10/02
Cinclare		11/22	09/18	11/19	10/11	10/27	10/11
Evan Hall				11/22	08/27		
F.Pearce				11/18	10/09	11/18	10/09
Georgia	08/25	12/13	10/15	11/08	10/11	10/18	10/11
Glenwood	09/17	12/02	10/12	11/02	09/26		
Lanaux	09/02	12/06	10/13	11/04	10/25	10/21	10/25
Levert-St.J.	09/08	12/01	10/01	11/17	09/20		
Magnolia	10/07	11/23	10/20	10/25	10/01	10/25	10/01
Oaklawn	08/27		10/02	10/28	09/06	10/20	09/06
Palo Alto	09/29	11/29	10/01				
R.Hebert	09/17	12/01	10/13	11/01	10/04	11/01	10/04

Table 3. Plant-cane sucrose yield (lbs/A) for eight commercial and six experimental varieties at ten outfield locations in 1993.

	Heavy textured soil locations			Light textured soil locations								NS from Best[2] %
Variety	All.[1]	Mag.	P.A.	B.S.	Cin.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	6041	7155	6546	5332	4555	6043	7378	6088	6099	6845	6208	80
CP70-321	5385	6333	----	5104	4513	6008	5346	4580	6435	6176	5542	44
CP72-370	5728	7276	5759	6533	5805	6019	6564	5700	6548	5659	6159	70
CP74-383	4794	7088	----	5006	6011	5965	5663	5374	6170	6204	5808	44
LCP82-089	5759	6705	6499	4637	3656	5189	5649	4412	6499	5988	5428	40
LHo83-153	5446	6527	5567	4333	4593	5727	7229	5438	6755	5786	5740	50
LCP85-384	5085	5488	8345	6371	6024	5666	7973	6432	4150	7487	6302	80
HoCP85-845	5212	7173	6687	6179	4908	6306	6460	5741	6644	5894	6120	70
LCP86-454	5832	6574	8032	5307	4160	5104	6564	6630	6228	6607	6044	70
LCP87-017	5248	6453	5741	3793	3261	5186	5541	5049	5587	5465	5121	20
L88-046	4599	5875	7223	6019	5641	4436	6878	6248	6316	5587	5944	60
L88-063	4959	5609	6613	4749	4363	4566	----	4746	5652	5088	5149	22
CP88-739	6032	6633	7321	5500	4664	5784	5928	5494	6346	----	5967	56
CP88-769	4874	7830	5530	6262	6039	6466	7540	5992	6374	5098	6201	80
Mean	5345	6627	6623	5405	4871	5633	6516	5566	6129	6016	5851	
$MSD_{.05}$	1222	1852	1847	929	769	923	1544	716	921	1096	671	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, P.A.-Palo Alto, B.S.-Bon Secour, Cin.-Cinclare, Geo.-Georgia, Gln.-Glenwood, Lan.-Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P<0.05$).

Table 4. Plant-cane yield of cane (tons/A) for eight commercial and six experimental varieties at ten outfield locations in 1993.

	Heavy textured soil locations			Light textured soil locations								NS from Best[2]
Variety	All.[1]	Mag.	P.A.	B.S.	Cin.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	22.6	32.2	31.1	20.9	18.1	22.0	29.8	23.6	23.9	28.8	25.3	70
CP70-321	21.6	30.5	----	21.0	17.1	23.1	23.8	19.1	25.3	25.8	23.0	44
CP72-370	22.1	29.7	23.4	25.5	22.7	22.7	26.4	23.9	25.9	22.9	24.5	70
CP74-383	19.0	33.2	----	22.3	24.0	23.6	26.3	24.7	27.2	27.3	25.3	78
LCP82-089	21.0	30.7	30.0	20.2	14.7	20.4	22.3	17.7	26.4	25.6	22.4	40
LHo83-153	21.8	30.9	25.7	18.3	18.4	23.9	29.8	22.6	27.3	25.1	24.4	50
LCP85-384	19.9	21.1	34.7	24.0	22.5	21.5	29.6	23.2	15.3	30.4	24.2	60
HoCP85-845	20.5	28.4	33.7	24.7	19.9	25.1	26.6	24.0	26.5	27.0	25.6	70
LCP86-454	21.3	31.8	35.0	20.6	16.6	20.3	26.8	25.8	25.4	26.7	24.8	60
LCP87-017	21.2	31.0	30.2	15.8	13.8	20.7	25.7	22.0	22.7	24.9	22.7	30
L88-046	17.3	26.8	31.5	23.8	22.0	16.5	29.5	25.2	26.0	23.5	24.5	60
L88-063	21.1	27.5	30.5	20.6	19.4	18.4	----	21.1	23.7	23.7	22.9	22
CP88-739	21.6	28.3	29.7	19.7	16.0	19.8	21.0	20.8	21.9	----	22.1	22
CP88-769	17.7	34.1	22.9	26.2	22.7	25.1	32.4	22.9	24.8	20.8	25.0	60
Mean	20.6	29.7	29.7	21.8	19.1	21.8	26.9	22.6	24.5	25.7	24.1	
$MSD_{.05}$	4.4	4.9	7.7	3.0	3.2	3.4	4.1	2.2	3.3	4.1	3.9	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, P.A.-Palo Alto, B.S.-Bon Secour, Cin.-Cinclare, Geo.-Georgia, Gln.-Glenwood, Lan.- Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 5. Plant-cane sucrose content (lbs/ton) of eight commercial and six experimental varieties at ten outfield locations in 1993.

	Heavy textured soil locations			Light textured soil locations								NS from Best[2]
Variety	All.[1]	Mag.	P.A.	B.S.	Cin.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	267	222	214	256	252	275	247	259	256	238	249	40
CP70-321	250	209	---	243	266	260	224	241	254	238	243	11
CP72-370	259	245	247	256	256	265	248	240	253	248	252	50
CP74-383	253	213	---	224	250	253	214	220	227	227	231	11
LCP82-089	275	218	217	228	248	253	254	248	246	235	244	40
LHo83-153	250	211	215	236	250	240	242	242	247	230	236	10
LCP85-384	258	260	240	265	267	266	268	277	271	247	262	80
HoCP85-845	253	252	198	250	248	253	244	240	251	218	241	10
LCP86-454	274	207	230	257	250	251	243	256	245	248	246	40
LCP87-017	248	208	189	241	238	251	216	229	247	220	229	0
L88-046	264	219	230	254	257	267	234	249	243	238	245	40
L88-063	236	202	217	230	225	250	---	225	238	215	226	11
CP88-739	279	234	246	279	292	292	282	264	289	---	273	100
CP88-769	275	229	242	239	266	258	233	263	257	245	251	40
Mean	260	224	224	247	255	259	242	247	252	234	245	
$MSD_{.05}$	24	26	31	21	21	30	28	26	14	22	8	

[1] All.-A.V.Allain& Sons, Mag.-Magnolia, P.A.-Palo Alto, B.S.-Bon Secour, Cin.-Cinclare, Geo.-Georgia, Gln.-Glenwood, Lan.- Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 6. Plant-cane stalk number (no./A) for eight commercial and six experimental varieties at ten outfield locations in 1993.

Varieties	Heavy textured soil locations			Light textured soil locations								NS from Best[2]
	All.[1]	Mag.	P.A.	B.S.	Cin.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	20550	21951	28575	17207	17503	17040	27245	17667	21290	24096	21312	30
CP70-321	21616	18918	-----	17574	13563	16420	18666	16957	21177	21234	18458	0
CP72-370	19689	20277	22908	22037	21480	18651	21152	21739	24385	20568	21289	60
CP74-383	18526	21602	-----	18195	21601	19749	21492	20240	25486	29105	21777	44
LCP82-089	17592	20322	25427	15906	12333	15727	16252	16923	23402	21950	18095	10
LHo83-153	25491	23977	25550	14496	18628	20927	26301	19690	26932	24302	22629	50
LCP85-384	20627	15851	33840	20078	21510	19109	24515	22893	18724	32231	22938	70
HoCP85-845	20616	19469	27699	20787	17818	20348	20527	22349	24834	24636	21908	50
LCP86-454	18800	20398	22399	13449	11382	14091	18091	14798	19773	18496	16923	10
LCP87-017	20057	25243	27893	13741	11810	17911	21920	17135	24196	22656	20224	40
L88-046	16960	20892	30507	20491	24841	15111	26421	22750	25975	27063	23245	70
L88-063	21747	20988	28571	19618	19409	16898	-----	21944	24572	23480	21914	67
CP88-739	18383	18525	24273	15659	15024	15364	18675	17222	17514	-----	17849	0
CP88-769	16440	23123	19366	21039	19645	19935	24201	19656	24551	23690	21165	50
Mean	19817	20716	26599	17978	17611	17725	21958	19426	23058	24076	20738	
$MSD_{.05}$	3872	5642	7252	3096	3471	3196	3439	2607	3260	2735	2285	

[1] All.-A.V.Allain& Sons, Mag.-Magnolia, P.A.-Palo Alto, B.S.-Bon Secour, Cin.-Cinclare, Geo.-Georgia, Gln.-Glenwood, Lan.- Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 7. Plant-cane stalk weights (lbs.) for eight commercial and six experimental varieties at ten outfield locations in 1993.

Variety	Heavy textured soil locations			Light textured soil locations							Mean	NS from Best[2]
	All.[1]	Mag.	P.A.	B.S.	Cin.	Geo.	Gln.	Lan.	R.H.	Lev.		
CP65-357	2.23	2.97	2.20	2.47	2.10	2.57	2.23	2.67	2.27	2.37	2.41	30
CP70-321	2.03	3.23	----	2.43	2.57	2.83	2.57	2.27	2.40	2.40	2.53	33
CP72-370	2.23	2.93	2.00	2.33	2.13	2.47	2.50	2.17	2.10	2.23	2.31	20
CP74-383	2.03	3.07	----	2.43	2.23	2.37	2.50	2.40	2.13	1.87	2.34	11
LCP82-089	2.40	3.03	2.40	2.57	2.40	2.60	2.77	2.10	2.27	2.33	2.49	40
LHo83-153	1.70	2.60	2.10	2.53	2.00	2.30	2.27	2.30	2.03	2.07	2.19	0
LCP85-384	1.93	2.70	2.07	2.40	2.10	2.23	2.43	2.07	1.63	1.90	2.15	0
HoCP85-845	2.00	2.97	2.43	2.37	2.23	2.47	2.60	2.13	2.13	2.20	2.35	10
LCP86-454	2.25	3.13	3.15	3.10	2.93	2.87	2.97	3.50	2.57	2.87	2.95	100
LCP87-017	2.10	2.45	2.20	2.30	2.33	2.30	2.37	2.53	1.87	2.20	2.26	10
L88-046	2.03	2.57	2.07	2.33	1.80	2.20	2.23	2.23	2.00	1.75	2.13	0
L88-063	1.93	2.60	2.13	2.10	2.00	2.17	----	1.93	1.97	2.00	2.09	0
CP88-739	2.33	3.07	2.43	2.53	2.13	2.60	2.27	2.40	2.50	----	2.47	44
CP88-769	2.17	2.97	2.37	2.50	2.30	2.53	2.67	2.33	2.00	1.77	2.36	30
Mean	2.10	2.89	2.26	2.46	2.23	2.47	2.49	2.36	2.13	2.16	2.36	
$MSD_{.05}$	0.30	0.42	0.57	0.42	0.29	0.30	0.35	0.35	0.18	0.31	0.13	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, P.A.-Palo Alto, B.S.-Bon Secour, Cin.-Cinclare, Geo.-Georgia, Gln.-Glenwood, Lan.-Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 8. First ratoon sucrose yield (lbs/A) for nine commercial and two experimental varieties at twelve outfield locations in 1993.

	Heavy textured soil locations				Light textured soil locations									NS from Best[2]
Variety	All.[1]	E.H.	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	4596	5938	5866	4552	5812	6617	5400	5109	3248	5279	5399	5952	5314	25
CP70-321	4646	6008	4154	5232	4588	7687	6045	5049	4914	3334	6589	4971	5268	17
CP72-370	5890	7200	4858	4960	6775	7100	6573	5752	4378	4020	6715	5186	5743	17
CP74-383	5958	6150	3731	5877	5305	8065	6183	4418	4535	4926	5722	5639	5542	8
CP79-318	5464	8165	4890	4760	6697	7886	6221	5511	4989	5994	5805	5218	5934	33
LCP82-089	6118	7329	6078	4680	6170	7219	7211	4760	4956	5419	5978	6144	6022	17
LHo83-153	6220	7035	5351	6288	5100	6858	6918	5148	4873	3840	6824	5827	5877	33
LCP85-384	7415	9285	4945	6934	8548	9550	8355	6920	6727	7827	8121	7602	7686	100
HoCP85-845	5033	6200	4081	4565	6429	6518	7302	5698	4049	6129	6332	5525	5655	17
LCP86-454	5350	8252	5647	6146	5000	7233	7515	4807	4967	6236	6460	6124	6145	42
LCP87-017	5967	7211	5697	4455	5603	7359	6701	4485	4869	5139	5938	5140	5714	8
Mean	5696	7128	5032	5314	6002	7463	6766	5244	4773	5282	6353	5757	5900	
$MSD_{.05}$	755	1701	1986	914	1487	1816	1119	1925	987	685	1138	1855	482	

[1] All.-A.V.Allain & Sons, E.H.-Evan Hall, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Gln.- Glenwood, Lan.-Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 9. First ratoon yield of cane (tons/A) for nine commercial and two experimental varieties at twelve outfield locations in 1993.

	Heavy textured soil locations				Light textured soil locations									NS from Best[2]
Variety	All.[1]	E.H.	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	19.5	23.4	24.3	14.5	24.1	23.0	24.0	23.6	15.7	23.2	21.7	22.3	21.6	25
CP70-321	19.7	23.6	18.4	16.3	19.3	25.9	23.7	23.9	20.7	17.1	24.1	20.5	21.1	33
CP72-370	24.0	27.7	19.9	15.7	26.1	25.3	25.6	23.7	18.2	19.2	26.4	19.4	22.5	42
CP74-383	26.5	25.9	16.7	19.3	24.5	29.0	28.1	24.3	19.9	24.7	24.1	23.6	23.9	50
CP79-318	22.5	28.0	20.6	15.8	25.9	27.2	22.9	24.5	20.2	26.1	23.9	20.4	23.1	42
LCP82-089	25.4	28.3	26.2	14.9	26.3	25.6	30.5	24.1	22.2	24.0	23.5	23.4	24.5	50
LHo83-153	26.3	28.7	24.1	21.4	23.8	24.9	28.3	24.4	21.6	20.3	27.0	22.9	24.5	58
LCP85-384	30.9	33.9	19.5	21.7	32.9	32.4	31.8	29.8	27.5	32.3	29.9	27.6	29.2	100
HoCP85-845	22.7	26.3	17.3	15.6	28.5	23.8	30.6	27.3	18.7	27.8	25.2	22.3	23.8	42
LCP86-454	24.4	32.3	23.8	19.6	20.4	24.2	31.8	23.7	23.7	25.6	24.7	24.7	24.9	58
LCP87-017	26.1	28.7	26.7	15.0	23.9	27.2	31.3	21.5	23.4	25.1	23.6	23.0	24.6	42
Mean	24.4	27.9	21.6	17.2	25.1	26.2	28.1	24.6	21.1	24.1	24.9	22.7	24.0	
$MSD_{.05}$	2.6	6.5	8.0	2.8	5.6	7.2	4.1	6.5	3.6	3.0	5.8	7.3	1.8	

[1] All.-A.V.Allain & Sons, E.H.-Evan Hall, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Gln.-Glenwood, Lan.-Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 10. First ratoon sucrose content (lbs/ton) for nine commercial and two experimental varieties at twelve outfield locations in 1993.

	Heavy textured soil locations				Light textured soil locations									NS from Best[2]
Variety	All.[1]	E.H.	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	235	254	241	314	240	288	226	216	206	228	250	266	247	75
CP70-321	235	254	225	321	235	298	256	210	237	195	273	243	249	58
CP72-370	247	260	244	316	259	281	257	241	241	210	254	266	256	83
CP74-383	225	238	223	304	217	278	220	181	227	202	241	239	233	25
CP79-318	243	292	238	300	258	290	271	224	248	230	244	256	257	92
LCP82-089	241	259	231	315	236	283	237	197	224	226	255	263	248	67
LHo83-153	237	245	222	295	213	277	245	210	226	189	253	254	240	33
LCP85-384	240	273	253	320	260	295	263	232	245	243	272	276	264	100
HoCP85-845	221	236	236	293	226	274	239	208	216	220	252	248	239	33
LCP86-454	219	255	238	314	243	298	236	202	209	244	261	246	247	50
LCP87-017	229	252	215	296	234	271	214	207	208	205	251	224	234	17
Mean	234	255	233	308	238	285	242	212	226	217	255	253	247	
$MSD_{.05}$	27	28	21	19	24	18	24	32	25	33	31	21	8	

[1] All.-A.V.Allain & Sons, E.H.-Evan Hall, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Gln.-Glenwood, Lan.-Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 11. First ratoon stalk number (no./A) for nine commercial and two experimental varieties at twelve outfield locations in 1993.

	Heavy textured soil locations				Light textured soil locations									NS from Best[2]
Variety	All.[1]	E.H.	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	19250	22136	20268	21537	21489	24974	21770	21543	14982	20309	22009	25747	21334	8
CP70-321	20965	20662	16301	19873	18985	23663	19637	19999	21737	16095	25112	21211	20353	0
CP72-370	23337	26331	19267	22346	26237	26977	25536	21499	18844	19481	28362	21397	23215	8
CP74-383	32113	28723	15780	24729	23763	29369	30796	25748	22944	24506	26385	31397	26354	42
CP79-318	24166	23863	19521	19562	23158	28240	20470	21940	19599	23774	25417	23788	22856	8
LCP82-089	27792	29974	25656	21266	23021	29123	29055	22925	24266	27130	27307	27331	26211	25
LHo83-153	26581	28115	25644	35199	21990	26315	30972	23266	24852	22935	30399	26451	26997	33
LCP85-384	34960	38478	22307	33098	32945	37083	33921	31022	34267	35877	35386	35259	33717	100
HoCP85-845	25152	27390	17361	21428	24922	25841	29002	25449	23738	25066	26561	26191	24842	17
LCP86-454	21011	28018	19022	21379	16461	18663	25583	15966	18858	19056	23589	22069	20806	0
LCP87-017	27904	30400	26122	20034	24316	27392	29710	21895	26878	24246	26260	26125	25940	17
Mean	25748	27809	20695	23677	23390	27058	26950	22828	22815	23384	26981	26088	24789	
$MSD_{.05}$	6258	5601	6923	6982	4371	8398	5272	6283	4881	3899	5361	6355	1898	

[1] All.-A.V.Allain & Sons, E.H.-Evan Hall, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Gln.-Glenwood, Lan.-Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P<0.05$).

Table 12. First ratoon stalk weights (lbs.) for nine commercial and two experimental varieties at twelve outfield locations in 1993.

	Heavy textured soil locations				Light textured soil locations									NS from Best[2]
Variety	All.[1]	E.H.	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Gln.	Lan.	R.H.	Lev.	Mean	
CP65-357	2.03	2.13	2.43	1.37	2.23	1.90	2.17	2.20	2.13	2.33	1.97	1.77	2.06	50
CP70-321	1.90	2.27	2.23	1.70	2.00	2.20	2.43	2.40	1.93	2.20	1.93	1.97	2.10	67
CP72-370	2.03	2.10	2.07	1.40	2.00	1.93	2.03	2.23	1.93	1.97	1.87	1.80	1.94	25
CP74-383	1.63	1.80	2.10	1.57	2.07	1.97	1.87	1.90	1.77	2.00	1.80	1.50	1.83	33
CP79-318	1.90	2.40	2.10	1.63	2.23	1.93	2.23	2.23	2.03	2.23	1.87	1.70	2.03	67
LCP82-089	1.87	1.87	2.03	1.37	2.30	1.77	2.10	2.13	1.83	1.75	1.73	1.70	1.87	17
LHo83-153	1.97	2.03	1.90	1.27	2.13	1.87	1.83	2.10	1.73	1.80	1.77	1.77	1.84	33
LCP85-384	1.77	1.77	1.73	1.30	2.03	1.77	1.90	1.93	1.63	1.83	1.70	1.57	1.74	8
HoCP85-845	1.80	1.93	2.00	1.47	2.30	1.87	2.13	2.17	1.60	2.23	1.90	1.70	1.93	25
LCP86-454	2.30	2.27	2.50	1.83	2.47	2.60	2.50	3.00	2.50	2.70	2.10	2.27	2.42	100
LCP87-017	1.87	1.90	2.03	1.50	1.97	2.03	2.10	1.97	1.77	2.07	1.80	1.73	1.89	8
Mean	1.92	2.03	2.10	1.49	2.16	1.98	2.12	2.21	1.90	2.11	1.86	1.77	1.97	
$MSD_{.05}$	0.42	0.40	0.41	0.32	0.43	0.39	0.32	0.32	0.32	0.62	0.44	0.42	0.09	

[1] All.-A.V.Allain & Sons, E.H.-Evan Hall, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Gln.-Glenwood, Lan.-Lanaux, R.H.-Ronald Hebert, Lev.-Levert-St. John.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 13. Second ratoon sucrose yield (lbs/A) for nine commercial and one experimental variety at nine outfield locations in 1993.

	Heavy textured soil locations			Light textured soil locations							NS from Best[2]
Variety	All.[1]	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Lan.	R.H.	Mean	
CP65-357	3196	4714	5690	4146	7838	----	6397	3276	4901	5020	25
CP70-321	5347	3818	5221	2825	8590	8495	5877	3086	6289	5505	33
CP72-370	4407	3157	5104	4899	8902	7723	5928	2909	6699	5525	11
CP74-383	5189	3957	5688	4896	7652	7531	5877	3952	6435	5686	33
CP79-318	3326	2238	5861	5621	8808	----	7404	3730	6500	5436	50
LCP82-089	5254	3650	6297	4545	8630	7002	4769	3439	6342	5548	22
LHo83-153	5159	2817	6948	4100	7863	----	5922	3272	6536	5327	13
LCP85-384	5342	2575	8432	6991	10500	8830	8129	5531	8476	7201	89
HoCP85-845	3753	4282	6935	5362	7860	----	7147	3195	6671	5585	50
LCP86-454	3835	4128	5879	4603	9281	9692	6117	3974	6558	5882	44
Mean	4481	3534	6205	4799	8569	8212	6329	3636	6541	5686	
$MSD_{.05}$	2337	1421	866	1762	1001	1543	1275	1926	1188	778	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Lan.-Lanaux, R.H.-Ronald Hebert.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 14. Second ratoon yield of cane (tons/A) for nine commercial and one experimental variety at nine outfield locations in 1993.

Variety	Heavy textured soil locations			Light textured soil locations						Mean	NS from Best[2]
	All.[1]	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Lan.	R.H.		
CP65-357	14.1	15.8	24.6	20.9	30.8	----	28.5	18.4	19.2	21.5	25
CP70-321	21.5	14.4	24.2	13.9	31.3	30.5	29.8	16.0	23.9	22.8	33
CP72-370	18.3	11.2	22.1	20.0	32.2	29.1	25.3	15.3	24.8	22.0	22
CP74-383	23.0	14.8	26.4	26.8	30.5	32.0	28.6	23.2	26.9	25.8	56
CP79-318	14.8	7.8	28.3	26.1	32.1	----	35.1	21.6	26.0	24.0	38
LCP82-089	21.8	13.3	27.8	23.0	33.4	26.7	25.4	21.0	25.4	24.2	33
LHo83-153	22.5	10.3	29.5	22.0	30.1	----	29.9	19.6	26.6	23.8	25
LCP85-384	23.8	8.8	32.7	31.6	39.8	31.0	35.2	26.2	31.4	28.9	89
HoCP85-845	16.5	16.2	29.4	23.7	29.3	----	30.8	19.7	26.2	23.7	25
LCP86-454	17.6	15.1	27.8	21.7	34.1	34.0	29.3	21.1	26.0	24.8	44
Mean	19.4	12.8	27.3	23.0	32.3	30.5	29.7	20.2	25.6	24.2	
$MSD_{.05}$	10.2	5.0	3.2	5.3	3.2	4.3	4.1	6.0	3.4	2.8	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Lan.-Lanaux, R.H.-Ronald Hebert.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 15. Second ratoon sucrose content (lbs/ton) for nine commercial and one experimental variety at nine outfield locations in 1993.

Variety	Heavy textured soil locations			Light textured soil locations							NS from Best[2]
	All.[1]	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Lan.	R.H.	Mean	
CP65-357	229	297	232	198	255	---	224	175	257	233	100
CP70-321	249	265	215	204	275	278	197	191	263	238	78
CP72-370	240	282	231	245	277	265	235	189	270	248	89
CP74-383	225	268	215	182	251	235	205	172	238	221	33
CP79-318	223	287	208	213	274	---	211	173	250	230	88
LCP82-089	241	275	227	197	259	263	188	163	249	229	44
LHo83-153	230	272	235	185	261	---	198	167	246	224	75
LCP85-384	223	292	259	222	264	285	231	207	270	250	100
HoCP85-845	228	264	235	226	268	---	232	159	255	233	75
LCP86-454	221	273	213	213	273	285	211	187	252	235	78
Mean	231	278	227	209	265	269	213	178	255	234	
$MSD_{.05}$	37	10	28	47	24	31	40	43	29	11	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Lan.-Lanaux, R.H.-Ronald Hebert.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 16. Second ratoon stalk number (no./A) for nine commercial and one experimental variety at nine outfield locations in 1993.

	Heavy textured soil locations			Light textured soil locations							NS from Best[2]
Variety	All.[1]	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Lan.	R.H.	Mean	
CP65-357	16558	17578	26889	23444	32359	-----	27917	18513	19261	22815	13
CP70-321	24532	16102	24184	17426	26239	28430	28547	16094	27549	23234	11
CP72-370	21848	14318	25222	23784	33861	27277	25944	17576	25785	23957	11
CP74-383	31092	16573	27997	31117	32542	36423	28071	27330	33031	29353	44
CP79-318	16898	8216	28052	32560	34764	-----	36661	21854	29162	26021	13
LCP82-089	25863	14022	30449	29928	36390	35133	25022	23579	28901	27699	22
LHo83-153	27303	12833	34820	26272	33855	-----	31203	23731	30584	27575	13
LCP85-384	35755	9958	38060	43048	49217	38868	41338	32102	42088	36715	89
HoCP85-845	20705	18770	32986	31491	30509	-----	31133	21081	32477	27232	13
LCP86-454	16937	15140	24638	22336	26432	29569	21896	16897	24301	21846	22
Mean	23749	14351	29330	28141	33865	32617	29726	21876	29314	26695	
$MSD_{.05}$	8405	5572	4482	6208	4342	10426	4969	5594	3168	3451	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Lan.-Lanaux, R.H.-Ronald Hebert.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 17. Second ratoon stalk weights (lbs.) for nine commercial and one experimental variety at nine outfield locations in 1993.

Variety	Heavy textured soil locations			Light textured soil locations						Mean	NS from Best[2]
	All.[1]	Mag.	Oak.	B.S.	Cin.	F.P.	Geo.	Lan.	R.H.		
CP65-357	1.67	1.80	1.87	1.80	1.93	----	2.07	2.00	2.00	1.89	50
CP70-321	1.73	1.77	2.00	1.63	2.40	2.17	2.17	2.00	1.73	1.96	44
CP72-370	1.67	1.60	1.77	1.63	1.90	2.17	1.97	1.73	1.93	1.82	44
CP74-383	1.47	1.77	1.90	1.70	1.90	1.77	2.03	1.73	1.63	1.77	11
CP79-318	1.70	1.87	2.03	1.63	1.83	----	1.90	1.97	1.77	1.84	38
LCP82-089	1.70	1.90	1.83	1.53	1.87	1.57	2.03	1.80	1.77	1.78	33
LHo83-153	1.67	1.60	1.70	1.70	1.77	----	1.90	1.63	1.73	1.71	25
LCP85-384	1.27	1.80	1.73	1.47	1.63	1.63	1.73	1.60	1.50	1.60	22
HoCP85-845	1.57	1.73	1.80	1.50	1.93	----	2.00	1.87	1.60	1.74	13
LCP86-454	2.07	2.00	2.27	1.97	2.55	2.30	2.67	2.47	2.13	2.26	100
Mean	1.65	1.78	1.89	1.66	1.95	1.93	2.05	1.88	1.78	1.84	
$MSD_{.05}$	0.40	0.21	0.22	0.51	0.23	0.27	0.33	0.28	0.24	0.11	

[1] All.-A.V.Allain & Sons, Mag.-Magnolia, Oak.-Oaklawn, B.S.-Bon Secour, Cin.-Cinclare, F.P.-Frank Pearce & Sons, Geo.-Georgia, Lan.-Lanaux, R.H.-Ronald Hebert.

[2] Percentage of locations where the variety was not significantly less than the highest yielding variety at that location as determined with the minimum significant difference ($P < 0.05$).

Table 18. Combined plant-cane means across locations from 1991 through 1993.

Variety	Tests[1]	Sucrose yield		Cane yield		Sucrose content		Stalk no.		Stalk weight	
		Mean	NS from best[2]	Mean	NS from best	Mean	NS from best	Mean	NS from best	Mean	NS from best
	no	lbs/A	%	T/A	%	lbs/T	%	no/A	%	lbs	%
CP65-357	32	6229	66	23.9	56	262	69	19844	22	2.4	28
CP70-321	31	5699	42	22.5	29	253	35	18869	10	2.4	22
CP74-383	31	6048	52	25.1	74	242	13	21098	32	2.4	19
LCP82-089	32	6015	56	23.4	53	257	56	19548	31	2.4	22
LHo83-153	32	6002	50	24.5	69	245	13	22623	50	2.2	0
LCP85-384	32	6838	94	25.7	88	266	94	24309	81	2.1	0
HoCP85-845	32	6419	75	25.9	85	248	19	22320	53	2.3	6
LCP86-454	31	6436	74	25.0	71	259	55	16884	10	3.0	100
$MSD_{.05}$		323		1.2		4		1071		0.1	

[1] Number of tests in which variety was harvested in 1991, 1992, and 1993.
[2] Percent of total tests the variety was not significantly different from the best variety for that trait in that test.

Table 19. Combined first ratoon means across outfield locations from 1992 through 1993.

Variety	Tests[1]	Sucrose yield		Cane yield		Sucrose content		Stalk no.		Stalk weight	
		Mean	NS from best[2]	Mean	NS from best	Mean	NS from best	Mean	NS from best	Mean	NS from best
	no	lbs/A	%	T/A	%	lbs/T	%	no/A	%	lbs	%
CP65-357	21	5630	29	21.4	33	264	86	21590	14	2.0	38
CP70-321	22	5766	27	21.7	41	265	68	21571	9	2.0	46
CP74-383	22	5960	18	24.2	59	248	27	26134	45	1.9	23
LCP82-089	22	6096	27	23.3	45	264	73	25250	27	1.9	9
LHo83-153	21	6020	29	23.7	57	255	38	26199	43	1.8	24
LCP85-384	22	7690	95	28.0	95	276	95	32536	100	1.7	5
HoCP85-845	21	6063	33	23.8	52	256	48	25499	34	1.9	14
LCP86-454	22	6448	23	24.5	64	264	73	20596	5	2.4	100
$MSD_{.05}$		411		1.5		5		1574		0.1	

[1] Number of tests in which variety was harvested in 1991, 1992, and 1993.
[2] Percent of total tests the variety was not significantly different from the best variety for that trait in that test.

Table 20. Second ratoon means across 1993 outfield locations.

Variety	Tests[1]	Sucrose yield		Cane yield		Sucrose content		Stalk no.		Stalk weight	
		Mean	NS from best[2]	Mean	NS from best	Mean	NS from best	Mean	NS from best	Mean	NS from best
	no	lbs/A	%	T/A	%	lbs/T	%	no/A	%	lbs	%
CP65-357	8	5020	25	21.5	25	233	100	22815	13	1.9	50
CP70-321	9	5505	33	22.8	33	238	78	23234	11	2.0	44
CP74-383	9	5686	33	25.8	56	221	33	29353	44	1.8	11
LCP82-089	9	5548	22	24.2	33	229	44	27699	22	1.8	33
LHo83-153	8	5327	13	23.8	25	224	75	27575	13	1.7	25
LCP85-384	9	7201	89	28.9	89	250	100	36715	89	1.6	22
HoCP85-845	8	5585	50	23.7	25	233	75	27232	13	1.7	13
LCP86-454	9	5882	44	24.8	44	235	78	21846	22	2.3	100
$MSD_{.05}$		778		2.8		11		3451		0.1	

[1] Number of tests in which variety was harvested in 1991, 1992, and 1993.
[2] Percent of total tests the variety was not significantly different from the best variety for that trait in that test.

Table 21. Combined plant-cane means across outfield locations from 1992 through 1993.

Variety	Tests[1]	Sucrose yield		Cane yield		Sucrose content		Stalk no.		Stalk weight	
		Mean	NS from best[2]	Mean	NS from best	Mean	NS from best	Mean	NS from best	Mean	NS from best
	no	lbs/A	%	T/A	%	lbs/T	%	no/A	%	lbs	%
CP65-357	21	6420	71	24.1	57	269	62	19970	24	2.4	29
CP70-321	22	5847	45	22.4	36	262	38	18205	5	2.5	27
CP72-370	22	6342	68	24.0	64	264	45	20101	32	2.4	18
CP74-383	22	5990	41	24.4	73	247	9	20793	18	2.3	9
LCP82-089	22	5915	55	22.6	50	263	45	18559	9	2.5	23
LHo83-153	21	6146	57	24.4	62	252	14	22540	53	2.2	0
LCP85-384	22	6905	91	25.1	82	276	91	23485	73	2.2	0
HoCP85-845	21	6518	76	25.6	81	255	14	21744	32	2.4	5
LCP86-454	22	6282	36	24.2	68	262	45	16444	5	3.0	100
LCP87-017	22	5691	41	23.4	55	244	5	20089	27	2.4	9
$MSD_{.05}$		391		1.8		5		1320		0.1	

[1] Number of tests in which variety was harvested in 1991, 1992, and 1993.

[2] Percent of total tests the variety was not significantly different from the best variety for that trait in that test.

Table 22. The percentage of plant-cane outfield observations in which the variety was rated in the designated category of post-harvest scrap during 1993.

Variety	None	Little	Some	Much	Very Much	Total[1]
CP65-357	57	24	13	3	3	30
CP70-321	71	22	7	--	--	27
CP72-370	84	13	3	--	--	30
CP74-383	78	18	4	--	--	27
LCP82-089	71	18	11	--	--	28
LHo83-153	67	20	10	--	3	30
LCP85-384	57	17	10	3	13	30
HoCP85-845	87	10	3	--	--	30
LCP86-454	82	14	4	--	--	28
LCP87-017	89	7	--	4	--	27
L88-046	57	11	14	14	4	28
L88-063	52	15	18	15	--	27
CP88-739	82	11	7	--	--	27
CP88-769	87	13	--	--	--	30

Table 23. The percentage of first ratoon outfield observations in which the variety was rated in the designated category of post-harvest scrap during 1993.

Variety	None	Little	Some	Much	Very Much	Total[1]
CP65-357	91	6	3	--	--	36
CP70-321	83	11	6	--	--	36
CP72-370	94	6	--	--	--	35
CP74-383	78	11	8	3	--	36
CP79-318	50	15	26	9	--	34
LCP82-089	94	6	--	--	--	35
LHo83-153	77	9	11	3	--	35
LCP85-384	67	22	8	3	--	36
HoCP85-845	97	3	--	--	--	36
LCP86-454	86	14	--	--	--	36
LCP87-017	94	6	--	--	--	36

[1]Total number of tests in which the variety was rated.

Table 24. The percentage of second ratoon outfield observations in which the variety was rated in the designated category of post-harvest scrap during 1993.

Variety	None	Little	Some	Much	Very Much	Total[1]
CP65-357	96	--	4	--	--	24
CP70-321	100	--	--	--	--	27
CP72-370	100	--	--	--	--	27
CP74-383	96	--	--	4	--	27
CP79-318	88	4	8	--	--	24
LCP82-089	100	--	--	--	--	27
LHo83-153	100	--	--	--	--	24
LCP85-384	89	7	4	--	--	27
HoCP85-845	100	--	--	--	--	24
LCP86-454	100	--	--	--	--	26

Table 25. The percentage of outfield observations across crops in which the variety was rated in the designated category of post-harvest scrap during 1993.

Variety	None	Little	Some	Much	Very Much	Total[1]
CP65-357	81	10	7	1	1	90
CP70-321	85	11	4	--	--	90
CP72-370	92	7	1	--	--	92
CP74-383	84	10	4	2	--	90
CP79-318	66	10	19	5	--	58
LCP82-089	89	8	3	--	--	90
LHo83-153	80	10	8	1	1	89
LCP85-384	70	16	8	2	4	93
HoCP85-845	95	4	1	--	--	90
LCP86-454	89	10	1	--	--	90
LCP87-017	92	6	--	2	--	63
L88-046	57	11	14	14	4	28
L88-063	51	15	19	15	--	27
CP88-739	82	11	7	--	--	27
CP88-769	87	13	--	--	--	30

[1]Total number of tests in which the variety was rated.

SUCROSE LABORATORY AT ST. GABRIEL

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Over 2,300 samples were processed at the St. Gabriel Sucrose Laboratory during the 1993 harvest season (Table 1). Standard laboratory procedures and the ABC Clarifier were used to measure the sucrose content of the juice. The juice was extracted via a three-roller mill for most of the samples (2,265). Ninety-three samples were analyzed for fiber via chip/press extraction. The program used to record the pol and brix data to computer files for calculation of sucrose, purity, and theoretical recoverable sugar (TRS) was updated. The feature added allows for the plot identification and bundle weight to be entered through use of the keyboard.

Table 1. Number of sugarcane samples processed at the St. Gabriel Sucrose Laboratory during the 1993 harvest season.

PROJECT	NUMBER OF SAMPLES
Cultural Practices and Fertility	
Ricaud	550
Hallmark	336
Viator	42
Selim	12
Entomology	20
Weed Science	135
Variety Program	
Infield	220
Line Trial	667
Nursery	270
Nursery (fiber)	93
TOTAL	2,355

This project was partially funded by the American Sugar Cane League.

IMPLEMENTATION OF A CROSS APPRAISAL SYSTEM WITHIN THE LOUISIANA SUGARCANE VARIETY DEVELOPMENT PROGRAM

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The Louisiana Sugarcane Variety Development Program currently uses 13 years from the initial crossing of parents until the year of variety release to develop new varieties. Each year, program personnel plant up to 75,000 seedlings from about 200 different crosses with the hopes of selecting, testing, and releasing one superior variety. The initial stage of crossing involves considerable work and decision making. The process encompasses choice of parents, greenhouse culture, photoperiod and temperature control, air layering (marcotting) of the stalks to enable physical convergence of the tassels, and crossing decisions based upon parental qualities and percent advancement knowledge. Percent advancement data is the percentage of each cross's progeny selected and advanced through the first four stages of selection. This process is time consuming, of questionable value, and available for only a limited number of crosses. Crossing decisions are further constrained by pollen fertility and flower availability. Photoperiod requirements to make each genotype flower vary and must be individually characterized to synchronize flowering with other clones. This characterization requires a minimum of one year, and more commonly two or three years, of culture and testing. Hence, the making of a sugarcane cross incurs considerable time and expense.

The objective is to develop practical methodology to conduct and use data from a cross appraisal system. Objective and subjective data comparisons were performed to determine the best way to collect data. Additional comparisons were made to test the repeatability of the predictions between seedling and clonal tests.

MATERIALS AND METHODS:

Research personnel at the St. Gabriel Research Station in St. Gabriel, LA grew sugarcane seedlings in Speedling™ trays under greenhouse conditions from January to April during 1992 and 1993. In April, the seedlings from the crosses were transplanted to the field in a randomized complete block design using two blocks. Progeny from the crosses were planted in plots of paired rows 1.8m apart. Each row was 4.8m long with a 1.2m space between plots and 0.4m between individual seedlings giving up to 16 plants per row and 32 plants per plot. Stalk number and stool number was determined in August 1993 on an individual row within plot basis for the 214 crosses planted in 1992. Stalk height was measured to the top visible dewlap on five randomly chosen stalks from different plants within in each row in each plot and block for a total of 20 observations per cross. The stalk diameter was recorded with a caliper at the bud groove near the middle of each of 20 randomly chosen stalks per cross in the same manner as with diameter. Individual measurements of height and diameter were from the same plants within the plot. Stalk weight and stool weight were estimated by assuming the stalk a cylinder with the stalk density equal to one. In 1993, 48 crosses were planted both at the St. Gabriel

This project was partially funded by the American Sugar Cane League.

Research Station and the Ardoyne Farm near Chacahoula, LA with the cooperation of the USDA-ARS personnel using a randomized complete design using two blocks. The crosses were planted in the same manner, and the same type of yield component data was collected in October 1993.

With the cooperation of USDA-ARS personnel, 50 crosses were planted on the Ardoyne Farm near Chacahoula, LA. These crosses were planted in paired rows 1.8m apart using up to 32 plants per row and 64 per plot. Plants were planted 46cm apart. Stalk number and stool number were determined in August 1993 on an individual row within plot basis. Data collection for stalk height and stalk diameter followed the above guidelines, and stalk weight and stool weight were estimated in the same manner.

To explore the within-family variance and the relationships among the individual plant data and first ratoon seedling family data, 25 crosses were randomly chosen and measured from the original 214 crosses. Within each row of the 25 families, in August, 1993, stalks per stool were recorded for five plants. Three stalks per stool were measured for individual height and diameter. These same data were collected for 25 families from the 48 plant-cane families planted at the USDA Station. Yield component data were collected following the above guidelines in October 1993 and at both the St. Gabriel and USDA Research Stations.

First clonal plant-cane family data were collected on the previous year's 25 crosses that were planted using four stalks from each of the 20 plants from each family that had at least four stalks per stool. A randomized complete block design using two replications was utilized. One block was in a Sharkey clay (very-fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts) and the other block was in a Commerce silt loam (fine-silty, mixed, nonacid, thermic Aeric Fluvaquents) at the St. Gabriel Research Station. Stalk number was determined in October 1993 on an individual plot basis. Data for stalk height and stalk diameter were recorded for five stalks per plot.

To explore the utility of a subjective ratings system, a substitute for the tedious objective data collection, the 214 crosses planted at St. Gabriel and the 50 crosses planted at the USDA Research Station were rated. Crosses were rated on a scale of 1 (best) to 9 (worst) for stalk height, stalk diameter, stalk weight, stalk number, and cane yield.

Family means and rankings for the 214, 50, and 48 family tests were obtained by using the SAS command PROC RANK (SAS, 1985). The data were sorted by stool weight, stalks per stool, stalk weight, stalk height, and stalk diameter.

Assuming a fully random model, variance components were obtained using the PROC VARCOMP with the REML option (SAS, 1985). A 10% mass selection equation was preformed to compare family selection versus non-family selection. When possible, genetic advance (GA) for various selection scenarios for among and within family selection were calculated using the equation:

$$MS_{10\%} = i_M\sigma_{PBCR}^2/(\sigma_C^2 + \sigma_{BC}^2 + \sigma_{RBC}^2 + \sigma_{PBCR}^2 + \sigma/_E^2)^{1/2}$$

$$GA_{family} = i_F\sigma_C^2/(\sigma_C^2 + \sigma_{BC}^2/b + \sigma_{RBC}^2/br + \sigma_{PBCR}^2/brp + \sigma_E^2/brps)^{1/2}$$

$$GA_{individual(fam)} = i_W\sigma_{PBCR}^2/(\sigma_{BC}^2 + \sigma_{RBC}^2 + \sigma_{PBCR}^2 + \sigma/_E^2)^{1/2}$$

$$GA_{combined} = GA_{family} + GA_{individual} = i_F\sigma_C^2/\sigma_{Pf}^2 + i_w\sigma_{PBCR}^2/\sigma_{Pw}^2$$

σ_{Pf}^2 = family phenotypic variance = $\sigma_C^2 + \sigma_{BC}^2/b + \sigma_{RBC}^2/br + \sigma_{PBCR}^2/brp + \sigma^2/brps$
σ_{Pw}^2 = within family phenotypic variance = $\sigma_{BC}^2 + \sigma_{RBC}^2 + \sigma_{PBCR}^2 + \sigma_E^2$
i_F = standardized among family selection coefficient,
i_W = standardized within family selection coefficient,
σ_C^2 = cross variance = among family variance,
σ_{BC}^2 = block by cross variance,
σ_{RBC}^2 = row(block cross) variance,
σ_{PBCR}^2 = plant(block row cross) = within family variance,
σ_E^2 = residual or error variance = within plant variance,
b = the number of blocks,
r = the number of rows,
p = the number of plants,
s = the number of stalks.

Selection rates were chosen to make the combined selection rate equal 10% either on a combined among family and within selected families basis or on an individual plant basis with no reference to family. Selection coefficients assumed population sizes of 200 families and 200 individuals within families, which are typical values for the breeding program.

REFERENCES:

SAS Institute Inc. 1985. SAS user's guide:basics, version 5 ed. SAS Institute, Cary H.C.

Table 1. Stalk height, stalk diameter, stalk weight mean squares and variance components, and standard errors for 203 families from the 1991 crossing series collected from the first ratoon crop seedlings in 1993.

Source	df	Stalk height		Stalk diameter		Stalk weight	
		MS†	VC±SE	MS	VC±SE x 10^{-2}	MS x 10^{-2}	VC±SE x 10^{-2}
		------ cm^2 ------		------ mm^2 ------		------ kg^2 ------	
Block	1	9441.8**	-	18.5	-	32.87	-
Cross	202	3752.9**	86.8 ±21.2	33.2**	99.6 ±17.9	13.12**	0.31 ±0.07
Block x cross	202	2009.6**	142.8 ±20.5	13.3	12.6 ±15.8	6.99**	0.20 ±0.08
Row(cross block)	406	586.3**	31.9 ±8.5	12.1	25.9 ±17.8	5.03*	0.15 ±0.07
Error	3248	426.4	426.4 ±10.6	10.8	10.8 ±26.8	4.30	4.29 ±0.11

† MS - mean square; VC - variance component; SE - standard error.
* significantly different at $\alpha = 0.05$. ** significantly different at $\alpha = 0.01$.

Table 2. Stalks per stool and stool weight mean squares and variance components, and standard errors for 203 families from the 1991 crossing series collected from first ratoon crop seedlings in 1993.

Source	df	Stalks per stool		Stool weight	
		MS†	VC±SE x 10^{-2}	MS	VC±SE x 10^{-2}
		-------- $no.^2$ --------		-------- kg^2 --------	
Block	1	177.38	-	77.25	-
Cross	202	2.71	12.39 ±8.73	2.15**	19.52 ±6.33
Block x cross	202	2.22**	36.19 ±12.27	1.37**	27.53 ±7.42
Error	3248	1.49	149.35 ±10.50	0.82	81.98 ±5.76

† MS - mean square; VC - variance component; SE - standard error.
** significantly different at $\alpha = 0.01$.

Table 3. Stalk height, stalk diameter, and stalk weight mean squares, variance components standard errors for 25 randomly selected families from the 1991 crossing series collected from first ratoon crop seedlings in 1993.

Source	df	Stalk height		Stalk diameter		Stalk weight	
		MS†	VC±SE	MS	VC±SE	MS x 10^{-2}	VC±SE x 10^{-2}
		------ cm^2 ------		------ mm^2 ------		------ kg^2 ------	
Block	1	31.5	-	9.4	-	3.8	-
Cross	24	8123.7	33.0 ±49.7	103.0**	1.4 ±0.5	3.5*	0.4 ±0.2
Block x cross	24	5989.5**	132.7 ±61.5	19.7	0.0 ±0.0	13.4*	0.1 ±0.1
Row(block cross)	50	2148.4**	56.4 ±31.8	17.4	0.0 ±0.0	7.6	0.0 ±0.0
Plant(block row cross)	400	1363.1**	350.2 ±35.9	21.6**	5.2 ±0.5	8.8	1.9 ±0.2
Error	1000	364.4	371.1 ±17.2	6.1	6.1 ±0.3	3.1	3.2 ±0.1

† MS - mean square; VC - variance component; SE - standard error.
* significantly different at $\alpha = 0.05$. ** significantly different at $\alpha = 0.01$.

Table 4. Stalks per stool and stool weight mean squares, variance components and standard errors for 25 randomly selected families from the 1991 crossing series collected from first ratoon crop seedlings in 1993.

Source	df	Stalks per stool		Stool Weight	
		MS†	VC±SE x 10^{-2}	MS	VC±SE x 10^{-2}
		-------- $no.^2$ --------		-------- kg^2 --------	
Block	1	269.0	-	36.2	-
Cross	24	59.8	31.8 ±32.2	30.3	18.3 ±18.8
Block x cross	24	38.1	0.0 ±0.0	20.7	2.0 ±25.2
Row(block cross)	50	44.2**	173.0 ±48.1	20.9**	82.6 ±28.6
Error	1400	16.8	1678.0 ±64.7	8.5	848.0 ±32.8

† MS - mean square; VC - variance component; SE - standard error.
** significantly different at $\alpha = 0.01$.

Table 5. Stalk height, stalk diameter, and stalk weight mean squares, variance components, and standard errors for 50 families from the 1991 USDA Houma crossing series collected from first ratoon crop seedlings in 1993.

Source	df	Stalk height		Stalk diameter		Stalk weight	
		MS†	VC±SE	MS	VC±SE x 10^{-2}	MS x 10^{-2}	VC±SE x 10^{-2}
		------ cm^2 ------		------ mm^2 ------		------ kg^2 ------	
Block	1	1288.2	-	0.0	-	2.53	-
Cross	49	3213.6**	99.2 ±34.7	41.2**	111.7 ±45.8	21.00**	0.67 ±0.23
Block x cross	49	230.0**	48.5 ±27.0	19.3	13.7 ±45.2	7.66*	0.25 ±0.16
Row(block cross)	100	744.2	71.9 ±21.4	17.5**	179.6 ±50.3	5.03*	0.26 ±0.16
Error	800	385.0	384.9 ±19.2	28.5	854.1 ±13.5	3.75	3.75 ±0.19

† MS - mean square; VC - variance component; SE - standard error.
* significantly different at $\alpha = 0.05$. ** significantly different at $\alpha = 0.01$.

Table 6. Stalks per stool and stool weight mean squares, variance components, and standard errors for 50 families from the 1991 USDA Houma crossing series collected from first ratoon crop seedlings in 1993.

Source	df	Stalks per stool		Stool weight	
		MS†	VC±SE x 10^{-2}	MS	VC±SE x 10^{-2}
		-------- kg^2 --------		-------- kg^2 --------	
Block	1	174.28	-	59.17	-
Cross	49	4.50	30.0 ±28.2	3.91**	49.6 ±22.0
Block x cross	49	3.29	33.9 ±38.1	1.93*	33.2 ±21.4
Error	900	2.62	261.7 ±37.0	1.26	126.1 ±17.8

† MS - mean square; VC - variance component; SE - standard error.
* significantly different at $\alpha = 0.05$. ** significantly different at $\alpha = 0.01$.

Table 7. Stalk height, stalk diameter, and stalk weight mean squares, variance components, and standard errors for 46 families from the 1992 crossing series collected on plant-cane seedlings at the St. Gabriel and Houma Research Stations in 1993.

Source	df	Stalk height		Stalk diameter		Stalk weight	
		MS†	VC ±SE	MS	VC ±SE x 10^{-2}	MS x 10^{-2}	VC ±SE x 10^{-2}
		------ cm^2 ------		------ mm^2 ------		------ kg^2 ------	
Loc	1	365500.8**	-	22.0	-	0.0	-
Block(loc)	2	28020.9**	-	116.9**	-	205.2**	-
Row(block loc)	4	615.6	-	6.7	-	6.2	-
Cross	45	4891.9	22.8 ±34.7	57.3**	98.0 ±33.0	44.8*	0.56 ±0.28
Cross x loc	45	3750.0**	101.6 ±45.9	19.9	13.5 ±3.50	24.1*	0.50 ±0.28
Cross x block(loc)	90	1958.9**	76.3 ±32.8	17.4	13.0 ±31.9	14.3	0.14 ±0.26
Cross x row(block loc)	180	1208.3**	58.1 ±26.7	15.9**	105.7 ±35.0	12.6**	0.71 ±0.28
Error	1433	912.4	913.1 ±34.5	10.6	1059 ±40.0	9.11	9.11 ±0.34

† MS - mean square; VC - variance component; SE - standard error.
* significantly different at $\alpha = 0.05$. ** significantly different at $\alpha = 0.01$.

Table 8. Stalks per stool and stool weight mean squares, variance components, and standard errors for 46 families from the 1992 crossing series on plant-cane seedlings at the St. Gabriel and Houma Research Stations in 1993.

Source	df	Stalks per stool		Stool weight	
		MS†	VC±SE x 10^{-2}	MS	VC±SE x 10^{-2}
		-------- $no.^2$ --------		-------- kg^2 --------	
Loc	1	57.7**	-	56.00**	-
Block(loc)	2	4.52	-	22.60**	-
Row(block loc)	4	2.00	-	2.40	-
Cross	45	5.23**	3.75 ±1.64	3.45**	20.52 ±11.30
Cross x loc	45	2.46*	0.82 ±1.54	1.88	6.01 ±12.10
Cross x block(loc)	90	2.07	2.27 ±1.79	1.49	7.20 ±14.70
Error	1613	1.63	16.2 ±1.73	1.49	148.86 ±15.90

† MS - mean square; VC - variance component; SE - standard error.
* significantly different at $\alpha = 0.05$. ** significantly different at $\alpha = 0.01$.

Table 9. Stalk height, stalk diameter, and stalk weight mean squares, variance components, and standard errors for 25 randomly selected families from the 1992 crossing series collected on plant-cane seedlings at the St. Gabriel and Houma Research Stations in 1993.

Source	df	Stalk height		Stalk diameter		Stalk weight	
		MS†	VC±SE	MS	VC±SE x 10^{-2}	MS x 10^{-2}	VC±SE x 10^{-2}
		------ cm^2 ------		------ mm^2 ------		------ kg^2 ------	
Loc	1	63861.3**	-	137.3**	-	9.46	-
Block(loc)	2	6320.1**	-	219.8**	-	57.01**	-
Row(block loc)	4	7455.3**	-	56.4**	-	44.28**	-
Cross	24	15158.1	63.7 ±51.2	179.8**	126.7 ±47.3	112.93**	0.64 ±0.30
Cross x loc	24	10713.5	51.2 ±57.7	31.8	0.0 ±0.0	37.62	0.15 ±0.22
Cross x block(loc)	48	6789.3**	120.3 ±55.8	41.9	26.3 ±29.8	289.42	0.22 ±0.25
Cross x row(loc block)	96	3704.5**	81.8 ±40.6	31.2	18.8 ±35.5	22.97	0.15 ±0.26
Plant(cross loc block row)	1000	2462.8**	710.4 ±47.3	28.3	45.8 ±54.6	20.54**	5.94 ±0.39
Error	4801	523.6	527.4 ±17.9	5.4	543.6 ±18.5	4.29	4.32 ±0.15

† MS - mean square; VC - variance component; SE - standard error.
** significantly different at $\alpha = 0.01$.

Table 10. Stalks per stool and stool weight mean squares, variance components, and standard errors for 25 randomly selected families from the 1992 crossing series collected on plant-cane seedlings at the St. Gabriel and Houma Research Stations in 1993.

Source	df	Stalks per stool		Stool weight	
		MS†	VC±SE	MS	VC±SE
		------- $no.^2$ -------		------- kg^2 -------	
Loc	1	744.61**	-	446.62**	-
Block(loc)	2	6.17	-	0.31	-
Row(loc block)	4	11.24	-	11.52	-
Cross	24	30.00**	0.47 ±0.24	13.39*	0.13 ±0.10
Cross x loc	24	11.26	0.06 ±0.17	8.26	0.00 ±0.00
Cross x block(loc)	48	8.77	0.00 ±0.00	7.83	0.00 ±0.00
Cross x row(loc block)	96	9.34	0.00 ±0.00	8.23	0.00 ±0.00
Error	801	10.83	10.56 ±0.49	8.60	8.49 ±0.39

† MS - mean square; VC - variance component; SE - standard error.
* significantly different at $\alpha = 0.05$. ** significantly different at $\alpha = 0.01$.

Table 11. Stalk height, stalk diameter, and stalk weight mean squares, variance components, and standard errors for 25 families clonal plots planted from first ratoon crop seedlings from the 1990 crossing series at the St. Gabriel Research Station.

Source	df	Stalk height		Stalk diameter		Stalk weight	
		MS†	VC±SE	MS	VC±SE x 10^{-2}	MS x 10^{-2}	VC±SE x 10^{-2}
		------ cm^2 ------		------ mm^2 ------		------ kg^2 ------	
Loc	1	1536396.6**	-	7.8	-	3429.12**	-
Block(loc)	2	29600.4**	-	174.1**	-	52.63**	-
Cross	24	9478.1*	28.6 ±31.3	110.2	19.2 ±38.5	95.90	0.13 ±0.33
Cross x loc	24	4006.1	13.0 ±28.1	64.8	33.4 ±44.7	56.97	0.35 ±0.40
Cross x block(loc)	48	3504.1	108.1 ±28.7	46.7	159.9 ±42.9	39.10	1.34 ±0.36
Plot(cross)	100	3732.5**	139.2 ±25.5	35.0**	128.4 ±26.5	30.31**	1.11 ±0.23
Error	2300	750.6	765.9 ±23.1	11.1	1111.1 ±33.6	9.13	9.12 ±0.28

† MS - mean square; VC - variance component; SE - standard error.
** significantly different at $\alpha = 0.01$.

Table 12. Stalk number and cane yield mean squares, variance components, and standard errors for 25 randomly planted clonal plots planted from first ratoon seedlings from the 1990 crossing series at the St. Gabriel Research Station.

Source	df	Stalk number		Cane yield	
		MS†	VC±SE	MS	VC±SE
		-------- $no.^2$ --------		-------- kg^2 --------	
Loc	1	12435.75**	-	676.06	-
Block(loc)	2	202.91	-	567.00	-
Cross	24	300.89	6.33 ±4.61	401.55	6.73 ±7.03
Cross x loc	24	158.35	0.00 ±0.00	266.96	8.73 ±7.93
Cross x block(loc)	48	184.29	2.77 ±6.37	164.76	0.00 ±0.00
Error	500	161.76	161.77 ±11.51	182.49	180.58 ±12.13

† MS - mean square; VC - variance component; SE - standard error.
** significantly different at $\alpha = 0.01$.

Table 13. Cane yield component genetic gains of combined family and individual selection intensities expressed as a percentage of the gains using mass selection with a 10% selection intensity for 203 crosses from the 1991 crossing series first ratoon families of individual plants at the St. Gabriel Research Station in 1993.

Trait	10% MS	Combination† 75% F and 13% I		Combination 50% F and 20% I		Combination 25% F and 40% I	
		Rep‡	No Rep	Rep	No Rep	Rep	No Rep
	% mean	----- Percent gains for 10% mass selection intensity -----					
Stalk height	21	108	106	103	100	87	82
Stalk diameter	1	416	402	620	594	767	821
Stalk weight	58	100	99	91	90	71	68

† 13% of the individuals selected from the best 75% families.
‡ rep = 2 blocks; 2 rows; 5 plants

Table 14. Cane yield component genetic gains of combined family and individual selection intensities expressed as a percentage of the gains using mass selection with a 10% selection intensity for 25 randomly selected families from the 1991 crossing series first ratoon families of individual plants at the St. Gabriel Research Station in 1993.

Trait	10% MS	Combination† 75% F and 13% I		Combination 50% F and 20% I		Combination 25% F and 40% I	
		Rep‡	No Rep	Rep	No Rep	Rep	No Rep
	% mean	----- Percent gains for 10% mass selection intensity -----					
Stalk height	15	100	98	92	90	74	70
Stalk diameter	12	115	114	117	115	111	106
Stalk weight	28	109	107	109	105	99	93
Stalks per stool	80	94	94	83	83	60	59
Stool weight	110	95	95	84	83	61	60

† 13% of the individuals selected from the best 75% families.
‡ rep = 2 blocks; 2 rows; 5 plants and for stalk height, stalk diameter, and stalk weight 3 stalks per plant

Table 15. Cane yield component genetic gains of combined family and individual selection intensities expressed as a percentage of the gains using mass selection with a 10% selection intensity for 50 crosses from the 1991 crossing series first ratoon families of individual plants at the USDA Research Station in Houma in 1993.

Trait	10% MS	Combination† 75% F and 13% I		Combination 50% F and 20% I		Combination 25% F and 40% I	
		Rep‡	No Rep	Rep	No Rep	Rep	No Rep
	% mean	----- Percent gains for 10% mass selection intensity -----					
Stalk height	17	113	111	109	106	96	91
Stalk diameter	20	104	103	98	96	80	77
Stalk weight	48	108	107	103	101	87	83

† 13% of the individuals selected from the best 75% families.
‡ rep = 2 blocks; 2 rows; 5 plants

Table 16. Cane yield component genetic gains of combined family and individual selection intensities expressed as a percentage of the gains using mass selection with a 10% selection intensity for 46 crosses from the 1992 crossing series plant-cane families of individual plants at the USDA Research Station in Houma and at the St. Gabriel Research Station in 1993.

Trait	10% MS	Combination† 75% F and 13% I		Combination 50% F and 20% I		Combination 25% F and 40% I	
		Rep‡	No Rep	Rep	No Rep	Rep	No Rep
	% mean	----- Percent gains for 10% mass selection intensity -----					
Stalk height	24	95	95	84	84	61	60
Stalk diameter	23	102	102	95	94	77	75
Stalk weight	57	99	99	90	89	70	69

† 13% of the individuals selected from the best 75% families.
‡ rep = 2 locations; 2 blocks; 2 rows; 5 plants.

Table 17. Cane yield component genetic gains of combined family and individual selection intensities expressed as a percentage of the gains using mass selection with a 10% selection intensity for 25 randomly selected families from the 1992 crossing series plant-cane families of individual plants at the USDA Research Station in Houma and at the St. Gabriel Research Station in 1993.

Trait	10% MS	Combination† 75% F and 13% I		Combination 50% F and 20% I		Combination 25% F and 40% I	
		Rep‡	No Rep	Rep	No Rep	Rep	No Rep
	% mean	----- Percent gains for 10% mass selection intensity -----					
Stalk height	16	101	100	95	92	77	74
Stalk diameter	1	256	249	379	365	525	503
Stalk weight	42	104	103	99	97	83	80
Stalks per stool	89	98	98	89	88	69	67
Stool weight	113	95	94	84	83	61	60

† 13% of the individuals selected from the best 75% families.
‡ rep = 2 loc; 2 blocks; 2 rows; 5 plants and for stalk height, stalk diameter, and stalk weight 3 stalks per plant.

Table 18. Cane yield component genetic gains of combined family and individual selection intensities expressed as a percentage of the gains using mass selection with a 10% selection intensity for 25 clonal plots from the 1990 crossing series planted from first ratoon families of individual plants at the St. Gabriel Research Station.

Trait	10% MS	Combination† 75% F and 13% I		Combination 50% F and 20% I		Combination 25% F and 40% I	
		Rep‡	No Rep	Rep	No Rep	Rep	No Rep
	% mean	---------- Percent gains for 10% mass selection intensity ----------					
Stalk height	22	96	96	86	85	64	63
Stalk diameter	21	94	94	83	83	59	59
Stalk weight	49	94	94	82	82	59	58

† 13% of the individuals selected from the best 75% families.
‡ rep = 2 locations; 2 blocks; 5 plants.

Table 19. Correlations for cane yield components for 25 randomly selected families from the 1990 crossing series in first ratoon seedlings and the same 25 families in plant-cane clonal plots.

	First Ratoon Seedlings				
First Clonal Plots	Stalk height†	Stalk diameter	Stalk weight	Stalk number	Plot yield
Stalk height	0.51	0.15	0.38	0.15	0.35
Stalk diameter	0.10	0.42	0.33	-0.11	0.18
Stalk weight	0.30	0.39	0.43	-0.01	0.31
Stalk number	0.29	-0.10	0.07	0.22	0.15
Plot yield	0.41	0.18	0.33	0.15	0.31

† standard deviation = 0.10.

Table 20. Yield component genetic and phenotypic correlations between objective data collection and subjective ratings on 203 families from the 1991 crossing series at the St. Gabriel Research Station.

	Subjective rating data				
Objective data	Stalk height†	Stalk diameter	Stalk weight	Stalk number	Plot yield
Stalk height	-1.01‡	0.11	-0.86	-0.62	-0.77
	(-0.66)	(0.00)	(-0.63)	(-0.45)	(-0.61)
Stalk diameter	0.01	-1.23	-0.32	0.31	-0.01
	(0.08)	(-0.46)	(-0.14)	(0.16)	(0.04)
Stalk weight	-0.81	-1.17	-1.00	-0.19	-0.62
	(-0.36)	(-0.35)	(-0.50)	(-0.16)	(-0.35)
Stalk number	-0.75	0.20	-0.55	-0.83	-0.75
	(-0.38)	(0.00)	(-0.30)	(-0.20)	(-0.31)
Plot yield	-0.89	-0.52	-0.87	-0.61	-0.78
	(-0.46)	(-0.20)	(-0.49)	(-0.22)	(-0.40)

† standard deviation = 0.05 ‡ genetic correlation = -1.01; phenoytypic correlation = (-0.66).

Table 21. First ratoon yield component genetic and phenotypic correlations between objective data collection and subjective ratings on 50 families from the 1991 crossing series at the USDA Research Station in Houma.

	Subjective rating data				
Objective data	Stalk height†	Stalk diameter	Stalk weight	Stalk number	Plot yield
Stalk height	-1.20‡	-0.75	-1.00	-1.04	-1.17
	(-0.66)	(-0.30)	(-0.67)	(-0.53)	(-0.67)
Stalk diameter	-0.81	-1.18	-0.96	-0.14	-0.51
	(-0.35)	(-0.45)	(-0.41)	(-0.02)	(-0.20)
Stalk weight	-1.04	-1.15	-1.08	-0.45	-0.80
	(-0.56)	(-0.48)	(-0.61)	(-0.24)	(-0.44)
Stalk number	-0.49	-0.80	-0.58	-0.85	-0.88
	(-0.51)	(-0.35)	(-0.48)	(-0.49)	(-0.51)
Plot yield	-0.92	-1.20	-0.99	-0.76	-1.02
	(-0.65)	(-0.49)	(-0.65)	(-0.47)	(-0.58)

† standard deviation = 0.10 ‡ genetic correlation = -1.20; phenoytypic correlation = (-0.66).

ASSESSMENT OF VARIETAL RESISTANCE TO THE SUGARCANE BORER

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Resistance to Diatraea saccharalis (F) damage (SCB) in sugarcane can be categorized predominately as antibiosis. Physical characteristics of the plant, such as leaf-sheath appression and rapid rind hardness development, contribute to the differential survival of young larvae among cultivars. Also, additional mortality factors in certain varieties seem to affect survival and development of larger larvae after they bore into the stalk. The use of percent bored internodes is means of ranking sugarcane cultivars on observed external evidence of D. saccharalis tunneling into the stalk. However, the degree of internal damage to the plant and the ultimate survival of D. saccharalis larvae are not addressed with this assessment. Varietal resistance to the latter stages of D. saccharalis injury is a primary goal of the entomology contribution to the LAES breeding program.

The L-91 series (40 cultivars) was planted on October 10,1992, in a four-replicated lattice design on the Lannaux Plantation, Killona, LA. Eight plots of each of the following commercially grown varieties (CP 70-321, CP 65-357, CP 74-383, and CP 79-318) were planted in this test to be used as standards for comparisons to the L91 cultivars. On October 28, 1993, a 15-stalk sample was cut from each replicate (4 replications = 60 stalks per cultivar). Each sugarcane stalk was examined to determine the number of bored internodes, moth emergence, and the total number of internodes. In this test no insecticides were used for control of the SCB; however, granular Lorsban was applied in late July to suppress the fire ants and enhance SCB infestation.

The overall sugarcane borer infestation was considerably less than in the 1992 test (1990 cultivars). The highest recorded SCB infestation was 36.66% bored internodes in L 91-255 with the highest moth emergence in the experiment(7,558/acre), which received a rating of 9, highest in susceptibility. Only one cultivar, L 90-190, received a rating of 2, slightly better than CP 70-321. Due to a change in the varietal program, 27 L91 cultivars were dropped from the breeding program prior to entomological data collection in this series.

Table 2 lists the first stubble test of the L-90 series planted on October 23, 1991, in a four-replicated lattice design on Lannaux Plantation. Data on percent bored internodes and moth emergence were collected on two L-90 series and four commerically cultvated varieties. SCB injury was highest in CP 74-383, which had 47.23% bored internodes and recieved a rating of a 9. L 90-190 had the least injury with only 15.83% bored internodes and recieved a rating of a 2, slightly better than that of CP 70-321.

Relative to this insect pest in sugarcane, a grower's primary objective is to minimize economic impact. There are two approaches to reduce the economic impact of pests. The first is to minimize the overall cost incurred in controlling the pest. Use of resistant varieties reduces pest damage at little or no cost to the grower. Resistance rating schemes traditionally have focused on the prevention of damage, whereas our research now provides an additional criterion. Incorporating the cultivar's pest survival rating allows us to flag varieties that enhance

D. saccharalis populations, involves little additional data collection, and enhances the efficiency and value of the entomological component in sugarcane breeding and varietal development of the LSU Agricultural Center.

Three of the most recent references used to form a basis for data collection in this research are:

Bessin, R.T., T.E. Reagan, and F.A. Martin 1990, A moth production index for evaluating sugarcane cultivars for resistance to the sugarcane borer (Lepidoptera:Pyralidae). J. Economic Entomology 83 (1):221-225.

Bessin, R.T., R.E. Stinner, and T.E. Reagan. 1991. Modeling the areawide impact of sugarcane varieties and predation of sugarcane borer populations in Southern Louisiana. Environmental Entomology 20:252-7.

Bessin, R.T., E.B. Moser, T.E. Reagan, and W.H. White. 1990. Analysis of percent bored internode data collected from sugarcane varietal resistance evaluations. J. Amer. Soc. Sugar Cane Technologist 9:8-22.

Table 1. Diatraea saccharalis damage and relative survival inside the stalk in four commercial and 13 experimental cultivars (1991 L series) during 1993 on the Lannaux Plantation, Killona, LA

Variety	% Bored Internodes	Relative * Survival	Moth Emergence	Rating
CP70-321	20.49abc	12.81	2,802	3
CP65-357	26.57 de	12.29	3,779	5
CP79-318	31.13 bcde	6.50	1,834	7
CP74-383	38.99 bcde	10.20	2,323	8
L 91-230	22.74abcd	9.30	2,290	4
L 91-232	26.27 bcd	10.59	3,498	5
L 91-250	31.28 de	7.96	2,825	7
L 91-255	36.66 e	18.00	7,558	9
L 91-261	18.30abc	8.73	2,237	3
L 91-264	18.21ab	8.98	1,713	3
L 91-266	24.81abcd	5.79	2,025	4
L 91-276	23.25abcd	11.45	2,802	4
L 91-281	26.84 bcde	5.37	1,012	5
L 91-285	26.86 bcde	12.50	2,836	5
L 91-286	22.96abcd	7.70	1,258	3
L 91-288	28.16 cde	16.39	1,505	5
L 91-290	15.39a	2.53	312	2

* Relative survival = 100 x no. exitholes / no. bored internodes
Means followed by same letter do not differ significantly(P=0.05,LSD).

Table 2. Diatraea saccharralis damage and relative survival inside the stalk of two L-90 series and four commerical varieties. First stubble on Lannaux Plantation, Killona, LA.

Variety	% Bored Internodes	Relative * Survival	Moth Emergence	Rating
CP70-321	25.69ab	7.59	1,612a	4
CP65-357	29.30abc	7.20	2,137ab	5
CP79-318	36.65 bc	12.32	5,161 bc	8
CP74-383	47.23 c	13.42	6,028 c	9
L 90-190	15.83a	14.45	2,955abc	2
L 90-191	29.79abc	4.5	1,522a	5

* Relative survival = 100 x no. exitholes / no. bored internodes
Means followed by same letter do not differ significantly (P=0.05,LSD).

INSECTICIDAL CONTROL OF THE SUGARCANE BORER
SMALL-PLOT TEST

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Season-long control of the sugarcane borer was evaluated in a randomized block design (5 replications) of plant cane cultivar CP74-383 at the St Gabriel Research Station, St Gabriel, LA. Insecticide treatments were applied over the sugarcane canopy with a CO_2 backpack sprayer on 30 July, 19 Aug, and 16 Sept when the SCB infestation exceeded the economic threshold (5% of the stalks containing live larvae in the leafsheaths). Retreatment of the experiment was initiated when control was lost in the Baythroid + Guthion mixture plots. Four 0.004 flat fan spray tips per 6-foot width of row at 32psi applied 20.1 gallons of finished formulation per acre. In addition, two granular insecticide treatments were applied using a 400-ml shaker jar calibrated to deliver the designated amount of formulation to the top of the sugarcane canopy (30 July, 19 Aug, and 16 Sept). Prior to the initiation of the experiment, 2 applications of Lorsban 15G were made (15 lbs per acre on each application) to suppress red imported fire ant predation (21 May and 6 July). The four Rohm & Haas (RH-2485 and RH-5992) treatments were applied with Triton CS-7 at 0.25% v/v, and the Javelin treatment was applied with Kinetic, at a rate of 0.25% v/v. Sugarcane borer damage was assessed by counting the bored internodes, exit holes, and total number of internodes from 100 randomly selected stalks of sugarcane in each treatment on October 19 and 21 (20 stalks per plot). Separation of means was by LSD. The results are presented in table 1.

With consistently heavy infestation pressure causing 66% bored internodes in the untreated check and an adult emergence of 7,650 moths per acre, eight of the treatments provided better than 80% control based on comparison of bored internodes. This included two rates each of the Rohm & Haas insect growth regulators RH-2485 and RH-5992, the Baythroid + Guthion half rate combination, and individual rates of the three pyrethroids Fury 1.5E, Asana XL, and Baythroid 2E. Javelin and two rates each of Lorsban 4E, MVP, and M-Peril provided less than 50% control of SCB, which was significantly ($P < 0.05$) different from the control received from the other treatments.

NOTE: The RH experimental insecticides are insect growth regulators that interfere with the molting process of Lepidopterous insects like the sugarcane borer. They are essentially non-toxic to nearly all other elements of the environment, including parasites, predators, pollinators, birds, and fish. Also, one of these products, RH-5992 (tebufenozide) with the trade name **MIMIC** has been assigned a special fast track labeling process for quicker registration by the Environmental Protection Agency.

Table 1. Small Plot Insecticide Trails of the Sugarcane Borer at the St. Gabriel Research Station, 1993.

Treatment	Rate lb/(AI)A	% Internodes Bored	% SCB Control	Moth emergence (No./acx10^2)[b]
RH-2485 2F	.06	8.6a	86.9	9.3ab
RH-5992 2F	.25	8.9a	86.9	4.9a
RH-5992 2F	.13	8.9a	86.5	5.3a
RH-2485 2F	.13	9.5a	85.6	7.7ab
Baythroid 2E +	.016+			
Guthion 2L	.45	10.0ab	84.9	10.1ab
Fury 1.5 EC	.035	10.0ab	84.9	10.5ab
Asana XL .66	.033	11.9abc	81.9	10.5ab
Baythroid 2E	.033	12.5abc	81.1	10.5ab
Asana XL .66 +	.025+			
Lorsban 4E	.50	16.8abc	74.6	12.6ab
Orthene 75S +	.14+			
Asana XL .66	.021	17.9abc	72.9	17.8abc
TD 2341-1 L	.50	20.8 bc	68.5	24.7abcd
Guthion 2L	.75	21.7 c	67.2	17.8abc
Javelin WP	.75[a]	37.4 d	43.4	36.0 bcd
Lorsban 4E	1.0	40.4 de	38.9	27.1 bcd
Lorsban 4E	.50	43.6 de	34.0	41.3 de
MVP L	1.0 gal[a]	44.9 de	32.1	51.8 e
M-Peril G	10.0 lbs[a]	46.3 de	29.9	48.6 e
MVP L	.5 gal[a]	48.2 ef	27.1	42.1 de
M-Peril G	5.0 lbs[a]	58.7 fg	11.2	80.6 f
Check	----	66.1 g	----	76.5 f
P>F(ANOVA)		.0001		.0001
LSD(0.05)		10.8		21.0

Means followed by same letter do not differ significantly (P=0.05,LSD).

[a] Actual amount of insecticide applied.

[b] Based on a plant population of 25,000 stalks per acre.

BIOLOGICAL CONTROL OF THE SUGARCANE BORER: FIRE ANT INTERFERENCE WITH PARASITE ESTABLISHMENT

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During the summer of 1993, a 5-acre field of CP 74-383 1st stubble on the St. Gabriel Station was divided into plots for evaluation of parasite and predator biological control of the sugarcane borer. A 4-replication experiment was conducted in a split plot arrangement where the presence or absence of fire ant predation (controlled with Lorsban) affected borer infestations in parasite and non-parasite release plots. The wasp parasite, Cotesia flavipes Cameron, which has become very effective as a biological control of the sugarcane borer in Texas (and somewhat less effective in Florida), was reared in the laboratory and released six times (5/26, 6/16, 6/30, 7/23, 8/2, 8/20) at eight field sites. A total of 17,000 parasite adults were released from cocoon clusters in this experiment. No sugarcane borer insecticides were used in this experiment.

The research assessment included (1) weekly monitoring of borer infestations, (2) collection of larvae and follow-up rearing in the laboratory to determine parasitization, (3) percent bored internode determinations, and (4) additional into season collection and rearing of borer larvae to determine possible maintenance of Cotesia flavipes on succeeding borer infestations in the field.

During this experiment, Cotesia parasite recovery in natural sugarcane borer infestations ranged from 2% on Sept. 9, to 11% on Aug. 26, and 33% on Aug. 18. Other than borer infestations and injury being heavier in plots without fire ants ($P < 0.05$), differences among treatments and any impact from parasite releases were not detected in this experiment. Additionally, during mid-October, 224 sugarcane borer larvae were collected and reared from this experiment, and no Cotesia parasites were yielded.

Thus, this research did not show promising potential for Cotesia flavipes releases to control the sugarcane borer in Louisiana. However, based on experiences of entomologists with U.S. Sugar Corporation in Florida, a modification of the parasite release technique could be expected to better facilitate establishment of the parasite.

It is felt that future research in this area should be a high priority for the Louisiana Sugarcane Industry, especially in view of the environmental vulnerability of current insecticide labels for control of the sugarcane borer.

Table 1. Percent Infestation and Injury from the Sugarcane Borer, Adult Moth Emergence, and Relative Survival (proportion of bored internodes with emergence) in Fire Ant Control and Non-control Treatments of Experiment to Release the parasite Cotesia flavipes at St. Gabriel in 1993.

Treatments	Dates of Infestation Sample							Mean % SCB Infstn	% Bored	Emergence #/Acre	Relative Survival %
	8/3	8/11	8/19	8/26	9/7	9/24	10/1				
1. Parasite Release & Ant Control	10	3.3	16.6	15	3.3	0	15	9.3	25.2	$10.75x10^3$	2.9
2. Parasite Release Only	3.3	1.6	10	5	0	1.6	8.3	4.3	11.6	$3.6x10^3$	6.0
3. Ant Control Only	3.3	10	15	8.3	3.3	6.6	20	9.5	28.6	$11.5x10^3$	3.9
4. Neither Ant Control nor Parasite Release	3.3	8.3	5	6.3	8.3	6.6	0	5.4	9.9	$3.6x10^3$	5.8

% infestation = 15 plants per plot X 4 replications; % bored internodes and emergence = 20 plants per plot

$P<0.05$ = Ant control; Differences were not detected with % borer infestation or any of the other late season assessments involving parasite release or the parasite interaction with predation.

AERIAL APPLICATION FOR CONTROL OF THE SUGARCANE BORER AND YELLOW SUGARCANE APHID

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Six insecticide treatments were tested for season-long control of the sugarcane borer at Blackberry Farm, located in Vacherie, LA. A randomized block design (4 replications) that incorporated 28 plots of SCB-susceptible plant cane was utilized. Plot size ranged from 0.91 to 2.3 acre (avgerging 1.7 acres). Each treatment was applied in water using a Cessna Ag Cat with swaths of 47.6 ft.(8 rows) delivering 2 gallons of finished formulation per acre. The plots were treated on 12 Aug when 5% of sugarcane stalks contained live larvae (3^{rd} instars or smaller) in the leaf sheaths. Mortality (live/dead) was assessed 3 days after treatment by collecting and identifying the stage of 15-20 larvae per plot. To determine the length of control, and if additional applications were needed, weekly infestation counts were made in each plot after the application. Yellow sugarcane aphid infestations also were monitored weekly by counting the number of YSA on the 3^{rd} or 4^{th} leaf below the whorl of 20 randomly selected plants in each plot. Infestations (SCB) remained below economic injury for the remainder of the growing season, and therefore no other applications were made. SCB damage was assessed by counting the number of bored internodes, exit holes, and the total number of internodes of 75 sugarcane stalks per plot #(5 sites/plot, 15 stalks/site) on 5 and 7 Oct. Separation of means was by LSD. The results are presented in Table 1.

All insecticide treatments that included a pyrethroid (Asana, Baythroid) provided excellent control of the SCB based both on % bored internodes and weekly monitoring of infestation counts ($P<0.05$). Though the initial % kill in Baythroid/Guthion and Furadan treatments showed a trend for being superior to the other treatments, only the Furadan treatment did not maintain infestations at or below the 5% level 2 and 3 weeks following application ($P<0.05$). The treatment in which aphids seemed most suppressed was Furadan 4F; however, Asana + Guthion, Asana + Orthene and Baythroid + Guthion combinations provided considerable reductions of aphids as compared to the pyrethroids alone ($P<0.05$).

Table 1. Percent bored internodes, % SCB infestation post application, % Kill and Average YSA per leaf in the Aerial Application Test, Vacherie, LA. 1993.

Treatment/form	Rate lb(AI)/a	% Bored Internodes	%SCB Infestation (Post Application) 23Aug	31Aug	9Sept	%Kill (3 day)	Avg YSA per leaf
Asana XL 0.66E	0.033	3.1a	1	1	1a	71	10.8b
Baythroid 2E	0.033	3.2a	0	0	2a	68	10.2b
Baythriod 2E + Guthion 2L	0.016 + 0.38	4.1ab	0	0	3a	87	2.7a
Orthene 75S + Asana XL 0.66E	0.18 + 0.021	4.4ab	1	5	3a	68	1.3a
Asana XL 0.66E + Guthion 2L	0.016 + 0.38	4.7ab	2	4	3a	77	0.8a
Furadan 4F	0.75	7.2 bc	0	10	13b	87	0.3a
Control	--	9.0 c	4	7	11b	--	2.4a
P>F(ANOVA)		0.008			0.003		0.008
LSD(0.05)		3.2			6.3		6.5

Means followed by same letter do not differ significantly (P=0.05,LSD).

STALK ROT, MOSAIC, SMUT, ROOT DISEASE, AND LEAF SCALD RESEARCH

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Stalk Rot Research:

The inheritance of resistance to red rot, caused by *Colletotrichum falcatum*, was studied in 40 crosses using 24 parents with variable levels of resistance. Stalks of 10 progeny from each cross and the parents were inoculated and held under controlled conditions. After 6 weeks, the stalks were split, and disease development was assessed for each clone. Using this traditional method for the evaluation of resistance, heritability estimates for resistance determined by mid-parent-offspring regression were low. The results suggest that genetic gain in resistance to red rot cannot be readily obtained in the breeding program by recurrent selection (selective crossing of resistant parents). However, the results of a field experiment addressing the effect of drought stress on disease severity suggest that resistance to red rot is affected by environmental stress. In view of this finding, the resistance heritability experiment was repeated in the field with inoculated and noninoculated stalks of each clone planted after 2 weeks of drought stress.

The effect of drought stress on red rot severity was studied in seven varieties, CP 65-357, CP 70-321, CP 72-370, CP 73-351, CP 74-383, LCP 82-89, and LCP 85-384. Stalk population reductions due to stress alone (in plots planted with stressed, noninoculated stalks) were only significant for CP 74-383, which appeared to be very sensitive to damage by drought stress. The stalk counts in stressed, inoculated plots were lower for all varieties, but CP 74-383, LCP 82-89, and CP 72-730 were most severely affected. The experiment was replanted during Fall, 1993.

The effect of stress due to water-logging on red rot severity also was studied in a field experiment with three varieties, CP 65-357, CP 70-321, and LCP 82-89. Heavy rainfall occurred during the winter months, and excess water stress resulted in considerable reductions in shoot numbers in noninoculated plots of all three varieties. Populations were lowest in the stressed, inoculated treatment for all three varieties, but the additional reductions resulting from inoculation were not significant.

Spring shoot and fall stalk populations were compared in billet vs. whole stalk plantings of five varieties. The spring stand was lower for CP 70-321; not different for CP 65-357, CP 72-370, and LCP 82-89; and higher for LCP 85-384 in billet-planted plots compared with whole stalk plots. The fall stalk counts were the same for all varieties except LCP 85-384 which had higher stalk counts in the billet planted plots. The occurrence of severe stalk rot is erratic, so the experiment was replanted during fall, 1993. The results of the stress/red rot interaction experiments suggest that stress has a strong effect on disease severity, so an experiment will be planted in fall, 1994, comparing billet vs. whole stalk plantings with and without drought stress.

Stalks of 34 commerical varieties and parents from the breeding program were inoculated with *Ceratocystis* to compare resistance levels to pineapple disease under controlled conditions. In this experiment, eight (24%), 12 (35%), and 14 (41%) clones were rated as resistant,

moderately susceptible, and highly susceptible, respectively. The only commerical variety rated as resistant was CP 79-318. CP 72-370, CP 76-331, LCP 82-89, LHo 83-153, and HoCP 85-845 were moderately susceptible, and CP 65-357, CP 70-321, CP 74-383, and LCP 85-384 were rated as highly susceptible. The wide range of resistance levels will allow a resistance heritability study to be conducted during 1994.

Mosaic Research:

Data collection was completed for a three-season study of the increase of mosaic, caused by sugarcane mosaic virus. Final disease incidence levels were variable between locations each season, but a seasonal pattern of disease increase over time was observed for each season. Rainfall and temperature data and weed community differences are factors being compared to attempt to explain differences between locations and seasons. In addition, spatial patterns of disease within fields were determined and are being studied to learn more about the epidemiology of mosaic in Louisiana.

Naturally occurring mosaic infection levels were monitored in varieties and experimental varieties planted in yield trails on farms (outfield tests) to evaluate levels of resistance to infection by the virus. The results of counts taken from LSU Agricultural Center and USDA-ARS Sugarcane Research Unit tests were combined in Table 1. Commercial varieties showing susceptibility to infection were CP 65-357 and CP 72-370. One experimental variety, LCP 86-454, showed moderate infection levels.

Smut Research:

Resistance levels to smut, caused by *Ustilago scitaminea*, were determined in an inoculated test for all experimental varieties in the selection program. The results are shown in Table 2. Seven of seven 1986-1988 series clones were resistant. Twenty-one (88%), two (8%), and one (4%) of 24, 1989 series clones; 24 (63%), 10 (26%), and four (11%) of 38, 1990 series clones; and 22 (66%), nine (25%), and five (14%) of 36, 1991 series clones were resistant, moderately and highly susceptible, respectively, to smut.

Root Disease Research:

The effects of treatment with fungicides and amendment of soil with various organic waste by-products on root disease and sugarcane growth were studied in pot experiments in the greenhouse. Metalaxyl controls root rot and increases plant growth in experiments with plants grown in soil infested with only *Pythium arrhenomanes*. However, results are inconsistent for applications to plants growing in sugarcane field soils. Treatment with formulations of metalaxyl with mancozeb or copper did not improve response consistency. Mancozeb, applied to the soil at high rates (100 or 400 ppm), gave erratic control of *Pythium* but consistently reduced disease symptoms and increased growth of plants in field soils. The explanations for these results are not clear, and the potential usefulness of fungicides continues to be uncertain. Additional pesticides are being tested for the ability to reduce root disease and increase sugarcane growth.

Municipal waste composts, yard waste compost, cotton gin trash compost, sugar mill filter press cake, and sewage sludge were tested for the ability to suppress root disease and

increase plant growth. Sewage sludge amendment reduced *Pythium* infection levels and disease symptom severity and increased plant growth in pathogenicity tests and field soil. Results were similar for amendment with cotton gin trash except *Pythium* colonization was not significantly reduced. Root rot symptoms were evident in plants grown in soil amended with mill filter press cake, but plant growth was increased. Amendment with yard waste compost resulted in erratic effects on disease and plant growth. Municipal waste compost amendment did not supress disease or increase plant growth. Compost amendments show some promise for suppressing root disease in sugarcane, and this research is continuing.

The possible effects of herbicide applications and graminaceous weeds on Pythium root rot epidemiology were studied. In a first experiment, treatment with asulam (Asulox), atrazine, glyphosate, metribuzin (Sencor), pendimethalin (Prowl), and terbacil (Sinbar) generally resulted in increased colonization of roots with *Pythium* for plants growing in sugarcane field soils. Reductions in plant growth were only greater for treatments with glyphosate and terbacil, both of which are injurious alone. In experiments to test the effect of herbicides on *Pythium* growth rate in culture, only pendimethalin was inhibitory to colony growth. Graminaceous weeds were effectively colonized by *Pythium arrhenomanes* and may have a role in the epidemiology of root rot as alternate or reservoir hosts for the pathogen.

High populations of nematodes were detected in soils at several locations where sugarcane plants were exhibiting poor growth. In a microplot experiment, sugarcane growth was significantly lower in nonsterile field soil from two locations than in sterile soil. For both soils, the growth reductions were correlated with nematode numbers and the *Pythium* colonization level. Additional research on possible interactions between nematodes and *Pythium* affecting sugarcane growth are in progress.

Leaf Scald Research:

Leaf scald, caused by *Xanthomonas albilineans*, is a new disease problem for the Louisiana sugarcane industry. During 1993, extensive surveys were conducted that determined the geographic distribution of the disease (Table 3) and which varieties were affected (Table 4). The surveys revealed that leaf scald is widely distributed but limited in occurrence. Leaf scald was not detected in commercial fields of CP 65-357 and CP 79-318; however, inoculated test results have shown that these varieties are susceptible. The number of fields of CP 70-321, CP 72-370, and LHo 83-153 affected and disease incidence within fields were low. A greater number of affected fields and higher disease incidence within fields were observed for CP 74-383 and LCP 82-89. Fields with the highest incidence of plants were in areas near the Gulf of Mexico over which Hurricane Andrew passed during August, 1992. Leaf scald was detected in numerous clones at the USDA-ARS research farm near Chacahoula, LA, and the disease was detected in yield trials and increase plots associated with the variety release and increase programs. Leaf scald was detected in numerous increase plots of newly released variety, HoCP 85-845, and the variety was not distributed to the industry.

Symptomatology was monitored in fields with diseased plants, and the effect of leaf scald on yield was studied. Leaf symptoms included bleaching; characteristic longitudinal, narrow, white "pencil lines"; and necrosis. Shoot and young stalk death also were observed. At one location, high disease incidence in CP 74-383 and drought stress resulted in extensive plant death

and severe losses. Visible disease incidence had a demonstrated adverse affect on yield in only one of four fields in which yield loss studies were conducted. Stalk sucrose content was lower in symptomatic compared with asymptomatic stalks in all four fields, and juice purity, fiber content, and stalk weight were lower in three, two, and one field, respectively.

Apparently, severe symptoms and yield losses are possible under Louisiana environmental conditions. However, it appears that severe losses only occur when high disease incidence occurs together with environmental stress. The breeding and variety selection programs have been adversely affected by leaf scald, and this will be detrimental to the sugarcane industry. The eventual direct impact on the industry, i.e. losses in the field, is uncertain. Extensive monitoring and research on leaf scald will continue during 1994.

Table 1. Sugarcane mosaic virus infection levels and resistance ratings in commercial and experimental varieties determined from natural infection occurring in yield trials on farms (outfield tests).

Variety	Percent Infection	Rating[a]	Experiemental Variety	Percent Infection	Rating[a]
CP 65-357	72.4	8	LCP 86-454	24.9	3
CP 70-321	5.3	1	LCP 87-17	4.6	1
CP 72-370	43.8	5	LCP 87-491	1.7	1
CP 74-383	8.3	1	L 88-46	10.3	2
CP 79-318	6.6	1	L 88-63	4.1	1
LCP 82-89	12.1	2	CP 88-702	0.5	1
LHo 83-153	0.3	1	CP 88-739	4.5	1
LCP 85-384	0.6	1	CP 88-764	2.7	1
HoCP 85-845	3.8	1	CP 88-769	5.2	1

[a] Resistance ratings assigned on a 1-9 scale in which 1-3 = resistant, 4-6 = moderately susceptible, and 7-9 = highly susceptible.

Table 2. Smut infection levels and resistance ratings determined from 1993 inoculated test.

Variety	Infection	Rating[a]	Variety	Infection	Rating[a]
CP 65-357	20.6	5	CP 89-843	9.0	3
CP 70-321	0.0	1	CP 89-846	15.6	4
CP 73-351	45.6	9	CP 89-848	0.0	1
CP 74-383	22.1	5	CP 89-855	0.0	1
CP 81-335	18.9	4	CP 89-859	0.0	1
LHo 83-153	7.7	3	CP 89-879	0.9	2
LCP 85-384	1.2	2	CP 89-884	0.4	2
HoCP 85-845	0.0	1	CP 89-885	5.6	3
LCP 86-454	4.6	2	CP 89-888	31.9	7
L 88-46	1.2	2	CP 89-889	3.8	2
L 88-63	0.9	2	L 90-170	41.1	9
CP 88-702	7.5	3	L 90-171	7.2	3
CP 88-739	0.0	1	L 90-176	2.3	2
CP 88-764	0.0	1	L 90-178	0.0	1
CP 88-769	0.0	1	L 90-181	0.0	1
L 89-106	5.4	3	L 90-188	5.7	3
L 89-107	16.1	4	L 90-190	23.3	5
L 89-113	5.9	3	L 90-191	7.0	3
L 89-115	0.0	1	L 90-194	16.6	4
L 89-137	3.7	2	L 90-198	1.2	2
L 89-152	0.0	1	L 90-200	0.0	1
CP 89-800	1.4	2	L 90-204	28.7	6
CP 89-805	0.0	1	L 90-207	30.5	7
CP 89-811	0.0	1	L 90-208	14.1	4
CP 89-816	6.5	3	L 90-216	8.3	3
CP 89-821	1.0	2	L 90-218	15.7	4
CP 89-825	5.2	3	L 90-223	0.0	1
CP 89-830	0.0	1	CP 90-912	8.6	3
CP 89-831	9.6	3	CP 90-921	0.0	1

Table 2 cont'd

CP 90-222	5.7	3	L 91-254	34.3	7
CP 90-923	22.5	5	L 91-255	4.8	2
CP 90-927	7.7	3	L 91-256	4.9	2
CP 90-932	0.0	1	L 91-257	0.0	1
CP 90-933	0.0	1	L 91-258	3.1	2
CP 90-935	0.0	1	L 91-261	16.0	4
CP 90-936	0.0	1	L 91-262	0.0	1
CP 90-941	5.7	3	L 91-264	19.1	4
CP 90-942	35.2	8	L 91-265	49.4	9
CP 90-950	32.4	7	L 91-266	31.5	7
CP 90-951	11.9	4	L 91-267	0.0	1
CP 90-952	13.6	4	L 91-268	9.1	3
CP 90-955	2.0	2	L 91-271	47.8	9
CP 90-956	0.0	1	L 91-272	21.1	5
CP 90-957	0.0	1	L 91-273	8.0	3
CP 90-959	0.0	1	L 91-274	11.3	4
CP 90-962	0.6	2	L 91-275	3.0	2
CP 90-963	20.0	4	L 91-276	7.0	3
CP 90-977	23.7	5	L 91-281	6.9	3
L 91-229	4.5	2	L 91-282	12.7	4
L 91-230	8.6	3	L 91-283	15.8	4
L 91-232	0.7	2	L 91-284	45.3	9
L 91-234	2.3	2	L 91-285	0.0	1
L 91-240	2.4	2	L 91-286	2.4	2
L 91-248	6.3	3	L 91-287	1.2	2
L 91-250	0.0	1	L 91-288	17.2	4
L 91-252	16.7	4	L 91-290	18.7	4
L 91-253	7.7	3			

[a]Resistance ratings assigned on a 1-9 scale in which 1-3 = resistant, 4-6 = moderately, susceptible, and 7-9 = highly susceptible.

Table 3. Occurence of leaf scald by parish.

Parish	Leaf scald detection sites
Ascension	Primary station
Assumption	Primary station, two secondary stations
Avoyelles	Primary station, cold tolerance tests
Iberia	One farm (multiple fields), one outfield test, two secondary stations
Iberville	St. Gabriel Branch Experiment Station
Lafayette	One farm
LaFourche	Three farms (one multiple fields), one outfield test, research plots
St. James	One outfield test, one secondary station
St. Martin	Two farms (one with multiple fields), three secondary stations
St. Mary	Two farms (one with multiple fields), primary station, two secondary stations
Terrebonne	Three farms (two with multiple fields), one outfield test, one secondary station, USDA research farm, Kleentek farm
Vermillion	Kleentek farm

Table 4. Summary of leaf scald detection from surveys conducted during 1993.

	Leaf scald detection sites		
Sources	No. of fields	No. of farms	No. of parishes
CP 65-357	0	0	0
CP 70-321	2	2	2
CP 72-370	3	3	3
CP 74-383	11	7	5
CP 79-318	0	0	0
LCP 82-89	9	8	5
LHo 83-153	1	1	1
LCP 85-384	0	0	0
HoCP 85-845	11	11	6
Research and increase plantings on farms	9	8	8

PLANT PATHOLOGY RESEARCH

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I am involved in three areas of work: 1) transformation of sugarcane plants with potentially agriculturally useful genes, 2) early detection of bacterial diseases of sugarcane using the polymerase chain reaction (PCR), and 3) cooperative work on sugarcane diseases in general.

1. Transformation Of Sugarcane Plants With Agriculturally Useful Genes

Project LABO2793 Sugarcane protoplast regeneration, fusion, transformation and disease resistance. The focus of this project is to transform intact sugarcane cells by electroporation or biolistic bombardment and regenerate transformed plants. Since the project was written, several reports of electroporation of intact monocot tissues have appeared. These protocols should work with sugarcane callus or suspension cells or cultured meristems and are currently being tried. This approach would preclude the need to use protoplasts, the regeneration of which remains a recalcitrant problem.

The availability of a gene gun in the Agronomy Department has allowed that approach to transform sugarcane cells or meristems. This work is being done with Dr. Scott Milligan and his student Francois Kayihura. We are attempting to develop a transformation system for sugarcane using the pAHC25 plasmid, which contains the selectable marker bar and the screenable gus gene both with the ubiquitin promoters. We also intend to introduce plasmid constructs containing the BT-toxin gene into borer-susceptible LCP 85-384. The ability to add genes for pest control to agronomically superior cultivars would be a great aid to the breeding and selection program. I have developed a system for regeneration of LCP 85-384 from callus that we will be using to regenerate plants from putatively transformed tissues.

2. Early Detection Of Bacterial Diseases Of Sugarcane By PCR

RSD and Leaf Scald (LS) are cryptic and latent diseases respectively. The best detection methods available require one hundred thousand to a million Cxx bacteria per ml of vascular sap to work reliably. The AIMA and bacterial titers develop late in the season and serological tests for leaf scald from plants are relatively insensitive. Management of both diseases would benefit from a sensitive assay that would detect the disease earlier in the growing season than is now possible. PCR has the potential to detect a single bacterium. This work is underway with my student Silvio Lopes. In the last year he has made good progress. We have a set of primers that give a unique band for Cxx (around 310 bp) and a smaller band for Xa (around 150 bp). Thus we are able to detect the presence of both pathogens in a single sample. Vascular sap extracts (2ul) have given positive signals at dilutions of 1:10, 1:100, 1:1000 and sometimes 1:10,000. We are trying to improve on the sample processing part of the assay to insure that the bacterial cells are broken open to allow exposure of the bacterial DNA to the PCR primers.

3. Cooperative Work On Sugarcane Diseases In General

With rising concern about keeping the selection materials that go off station free of RSD and LS, I have sampled and tested samples with and for Scott Milligan, Jeff Hoy, and Keith Bischoff in order to get a handle on the extent of the RSD problem at St. Gabriel. Using AIMA and dark-field microscopy, approximately 50% of the 1000 or so samples tested positive. Individual stalks of all varieties scheduled for introduction to the new variety seed increase program were tested for RSD. Only two varieties had stalks that tested positive. Only stalks that tested negative for RSD were used for introductions to the primary increase station. RSD was detected in 3 of the 42 assignments in the 93 series. This diagnostic information is essential in helping to maintain clean planting material and to identify prospective RSD-susceptible clones in the breeding and selection program.

Table 1. RSD Sampling From St. Gabriel Experiment Station Plots During Fall 1993. Number Positive / Number Sampled.

	Area				
	Cultural		Variety Program		
Variety	Practices	Pathology	Block 1	Block 3	Station
CP65-357	12/12	9/20; 0/6	1/6		
CP70-321	2/12	1/20; 0/6	1/6	1/12	
CP70-321 HWT				0/20	
CP72-370	11/11	0/20; 0/6	6/6		
CP74-383	12/12	13/20	6/6		
CP79-318			6/6		
CP76-331			2/6		
LCP82-89		20/20; 4/6	6/6	4/6	20/20
LCP82-89 HWT				1/6	
LHo83-153	11/12		6/6		
LCP85-384	3/12		3/6		4/20
LCP86-454				0/6	

In discussions with Jeff Hoy, we have begun cooperative work on RSD and LS with Mike Grisham to address some of the problems regarding RSD and LS in our cultivars. Several kinds of experiments are being done. Fourteen cultivars are being ranked for their susceptibility to RSD and LS by a greenhouse infectivity titration experiment. ED50 values will allow ranking of these cultivars, and I expect these rankings to closely track the results of RSD and LS harvester spread tests using eight cultivars that are in the ground at St Gabriel and Houma. Silvio Lopes and I are involved in evaluating the PCR test against serological and other assays in the evaluation of these experiments.

WEED CONTROL RESEARCH IN SUGARCANE

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In 1993, weed control research conducted in sugarcane included the evaluation of experimental and labeled herbicides for sugarcane tolerance and for control of weeds common in sugarcane fields. Research specifically addressed control of itchgrass, johnsongrass, bermudagrass, vaseygrass, and ryegrass. Studies were also conducted to evaluate weed control in fallow fields and in succession-planted sugarcane. Below is a brief summary of research results. The project personnel are appreciative of the support received through the American Sugar Cane League and to Mike Melancon and Ronnie Roberts (St. Martin Parish); Joe Beaud, David Stewart, and Steve Loupe (Pointe Coupee Parish); Ed Richard (Terrebonne Parish); Stan and David Rodrigue (St. John Parish); Bob Robert (West Baton Rouge Parish); Mike Waguespack (St. James Parish); and Donnie Vaughn (East Baton Rouge Parish) who allowed us to conduct research on their farms.

Research With New Herbicides:

Experimental herbicides evaluated in 1993 included MON 13200, MON 12000, F-6285, Command, RH 1658, Goal, and CGA 152005. Sugarcane tolerance to all herbicides applied to emerged cane was acceptable. Itchgrass control with Command treatments was at least 86% and was equivalent to that of Prowl plus atrazine. Early season sugarcane injury with Command was not reflected in reduced stalk height. Itchgrass was controlled at least 85% with a spring application of MON 13211 at 0.75 lb/A or more. MON 12000 provided impressive control of nutsedge. F-6285 provided broadleaf weed control equivalent to atrazine with activity preemergence and postemergence. Goal and CGA 152005 showed promise for morningglory control when applied postemergence.

Asulox Research:

Cultivar Sensitivity to Time of Application. Field studies were conducted to compare johnsongrass control and injury to three sugarcane cultivars with Asulox at 4 quarts/A applied April 15, May 1, May 15, or June 1. In plant cane at St. Gabriel, LA when seedling johnsongrass predominated, greatest johnsongrass control (75%) and lowest johnsongrass panicle counts were observed with a May 15 application compared with April 15 or May 1. Sugarcane stalk population in August was equivalent for April and May applications and was greater than for June or when no Asulox was applied. Sugarcane yield and sugar yield were 18% higher when Asulox was applied May 15 rather than June 15, but equivalent to application April 15 or May 1. When rhizome johnsongrass was predominant in plant cane at Houma, LA, Asulox application April 15, May 1, or May 15 resulted in equivalent johnsongrass control, sugarcane stalk population and height in August, and sugarcane and sugar yield, greater than for the June 15 application. Sugarcane cultivars were most sensitive to Asulox application in June and injury ranking was 'CP 72-370' > 'LCP 82-89' ≥ 'CP 70-321'. Even when johnsongrass was effectively controlled in plant cane, weed population the following year was controlled no more than 62% regardless of Asulox application time. Sugarcane and sugar yield in the stubble crop

were reduced by as much as 50% compared with the previous year.

Interaction With Time of Fertilization. Field studies were conducted to evaluate johnsongrass control with Asulox at 4 quarts/A applied to rhizomatous johnsongrass 3 days before fertilization (DBF), 0, 3, 7, 10, or 14 days after fertilization (DAF). Fertilizer (18-6-12) was applied at either 100 or 200 lb N/A with a ground driven liquid fertilizer injection system equipped with knives spaced 70 cm apart on each side of the top of the row. Johnsongrass was controlled 60 to 78% with Asulox applied 3 DBF, which was greater than when applied 0, 3, 7, or 10 DAF. Corresponding increases in johnsongrass dry biomass were noted following Asulox application 3, 7, 10, or 14 DAF compared with 3 DBF. Differences in johnsongrass control were reflected in regrowth 10 weeks after Asulox application. Reduced johnsongrass control observed when Asulox was applied after fertilization appears related to root pruning and subsequent stress associated with the fertilizer operation. Results help to explain the inconsistency in johnsongrass control often observed with Asulox application following fertilization.

Critical Rainfree Period. Field studies were conducted to determine the critical rainfree period for johnsongrass when Asulox at 4 quarts/A was applied with Agridex crop oil concentrate or DyneAmic commercially blended organosilicone/crop oil concentrate premix. A rainfall simulator was used to deliver the equivalent of 0.5 inches of water in 15 minutes at 0, 3, 6, 12, 24, and 48 hours after herbicide treatment (HAT). Johnsongrass was treated at the boot stage to 70% seedhead emergence. Visual johnsongrass control 42 days after treatment (DAT) was maximized at 65 to 70% in 2 of 3 studies and at 80% in one study, and differences between adjuvants was not observed. Predicted critical rainfree period at which greatest johnsongrass control was obtained ranged from 8 to 20 HAT and was related to plant growth stage at time of Asulox application and environmental conditions following herbicide application. Johnsongrass green weight biomass measured 42 DAT in the three studies was reduced compared with the 48 hour washoff treatment 58, 46, and 64% at the predicted critical rainfree periods of 3, 8, and 18 HAT, respectively. Variation in the critical rainfree period is indicative of the variability in johnsongrass control commonly observed with Asulox.

Additive Research. Johnsongrass was controlled 80% with Asulox plus Dyneamic, which was greater than for Asulox alone or Asulox plus Penetrator, Ag-98, Dyneamic plus Quest, Induce, LI 700 plus ACA plus ammonium sulfate, or surfactant WK. Control was 47, 53, and 59% for Asulox with LI 700 plus ACA plus ammonium sulfate, Ag-98, and Dyneamic plus Quest, respectively.

Research is also underway to evaluate the stability of Asulox as affected by water pH and standing time.

Karmex/Direx Research:

Karmex/Direx applied in combination with Prowl controlled 2 to 3 leaf itchgrass without injuring emerged sugarcane. This research as well as research conducted previously was helpful in obtaining label changes which now allow for their use after cane has emerged in spring and as a layby application. Prior to this research the only viable option for control of emerged itchgrass in spring was shaving or Asulox.

Roundup and Oust Research:

Studies are underway to evaluate Oust for johnsongrass control in fallow, after cane harvest for seed in August, after harvest in November, and in succession planting. Additionally, Oust is being evaluated for control of itchgrass in fallow and after planting. In these studies both weed control and sugarcane injury were evaluated.

Johnsongrass Control in Succession Planted Cane. Johnsongrass was controlled 93 to 98% with Oust applied preemergence at 1, 2, and 3 ounces/A after sugarcane was succession planted on October 15, 1993. Sencor and Sinbar controlled johnsongrass 22 to 31%. When Oust was applied at 2 and 3 ounces/A, emergence of sugarcane shoots on January 6, 1994 was generally less than for Sencor or Sinbar.

Johnsongrass Control After Cane Harvest for Seed. Sugarcane was harvested on August 26, 1993 and Oust treatments were applied immediately after harvest. Johnsongrass control 21 DAT was 71, 76, and 87% for Oust at 1, 2, and 3 ounces/A, respectively. Sinbar, Sencor, Prowl plus atrazine, and atrazine alone controlled no more than 36% of johnsongrass. On October 28, johnsongrass control with the Oust treatments was no more than 69%. Asulox which was applied postemergence on September 17 controlled 72% of johnsongrass 41 DAT.

Johnsongrass Control With Roundup Under Simulated Rainfall. Simulated rainfall studies were conducted July 26 and Aug. 28, 1993, at Baton Rouge to evaluate rhizome johnsongrass control with Roundup D-Pak and spray additives under field conditions. A split-plot experimental design replicated four times was used with whole plots as time between herbicide treatment and rainfall and subplots as Roundup D-Pak plus spray additive. Whole plots received either no rainfall or rainfall at 15 or 60 minutes after herbicide application using a rainfall simulator delivering 0.5 inch of water in 15 minutes. Herbicide treatments included Roundup D-Pak at 30 oz/A combined with Kinetic HV at 0.25% (v/v), LI 700 or DyneAmic at 0.5% (v/v), Induce or Activator 90 at 1.0% (v/v), or LI 700 plus ACA at 1.0% (v/v) + 1 oz/A. Applications were made to rhizome johnsongrass 41 to 75 inches tall with 15 to 20% seedhead emergence. Statistical analysis showed no difference between studies and a rainfall time by additive interaction was not noted for johnsongrass control. Averaged across rainfall times, johnsongrass control 7 DAT with Roundup D-Pak was similar regardless of additive used and was no greater than 45%. Johnsongrass control with Roundup D-Pak, averaged across additives, was increased as simulated rainfall was delayed from 15 minutes (16%) to 60 minutes (30%), but was less than with no rainfall (81%). Averaged across rainfall times, johnsongrass was controlled with Roundup D-Pak no more than 62% 14 DAT and differences were not noted among additives. Johnsongrass control 14 DAT averaged 27 and 54% for the 15 and 60 minute rainfall times, respectively, which was less than with no rainfall (93%).

Johnsongrass Control With Roundup D-Pak and Additives. Field studies were conducted July 23 and Aug. 16, 1993, to evaluate effectiveness of various additives with Roundup D-Pak for rhizome johnsongrass control. Herbicide treatments included Roundup D-Pak at 20 oz/A plus Kinetic HV, Herbex, or Break-Thru at 0.25% (v/v), DyneAmic, HM 9207A, or LI 700 at 0.5% (v/v), Penetrator Plus, Agridex, or Induce at 1.0% (v/v), HM 9207A plus Quest at 0.50% + 0.25% (v/v), or Induce plus 2,4-D at 1.0% (v/v) + 16 oz/A. Johnsongrass was 36 to 60 inches tall with 10 to 15% seedheads emerged when herbicide treatments were applied. Roundup D-

Pak with Herbex, Break-Thru, or HM 9207A plus Quest 7 DAT controlled johnsongrass around 55%, which was significantly greater than that of Roundup D-Pak plus the Induce standard (43%). Roundup D-Pak with other additives controlled johnsongrass equivalent to that of Roundup D-Pak plus Induce. Addition of Herbex, Break-Thru, or HM 9207A alone or plus Quest controlled 64 to 74% of johnsongrass 14 DAT, which was superior to that of Roundup D-Pak plus Induce (53%). Johnsongrass control 7 and 14 DAT was reduced with the addition of 2,4-D to Roundup D-Pak plus Induce compared with other Roundup D-Pak/additive combinations.

Even though johnsongrass control in the Roundup D-Pak/additive studies ranged from 27 to 93% 14 DAT, no regrowth occurred following topgrowth removal. Apparently absorption and translocation of Roundup D-Pak, regardless of additive, was sufficient for complete johnsongrass control even with simulated rainfall 15 minutes after application.

Itchgrass Control in Fallow and After Planting. In the first study, Oust (1, 2, or 3 ounces/A), atrazine, or no herbicide was applied on July 16 after rows were formed. Rows were opened and sugarcane was hand planted on August 23. Cane was covered with 4 to 6 inches of soil and rows were packed twice. After-planting treatments included Oust, Prowl plus atrazine, or atrazine alone. Itchgrass control just prior to planting was at least 93% for the Oust treatments. Thirty days after herbicides were applied to the planted bed, itchgrass control was no more than 70% for Oust treatments applied July 16. When Prowl plus atrazine at planting followed Oust in fallow, control was at least 94%. When no herbicide was applied July 16, itchgrass was controlled 85 to 95% with Oust after planting. Injury to sugarcane was not observed following Oust application July 16, but was as high as 37% when Oust at 3 ounces/A was applied after planting. Of interest was that 46% sugarcane injury was noted when atrazine was applied July 16 followed by Prowl plus atrazine after planting. Sugarcane injury can probably be attributed to the extensive itchgrass green residue present on the sugarcane beds at planting. In another study when fallow treatments were not applied, Prowl plus atrazine after planting controlled itchgrass 95%. Itchgrass control with Oust applied after planting was 71 to 75% at 1 ounce/A, 83 to 86% at 2 ounces/A, and 93 to 94% at 3 ounces/A. Oust at 3 ounces/A controlled itchgrass equivalent to that of Prowl plus atrazine. Sugarcane injury was not noted for any of the herbicide treatments.

Bermudagrass Control in Fallow:

Roundup, Oust, and Tillage Fallow Programs. Bermudagrass ground cover on September 16 was no more than 9% when Roundup was used in conjunction with tillage. When Oust was applied June 1, bermudagrass ground cover on September 16 was 100%. Observations indicated that Oust application prevented bermudagrass from reestablishing for around 45 days. Even though bermudagrass was the predominant weed present, Oust was very effective on johnsongrass, broadleaf weeds, and nutsedge. Sugarcane was planted on September 24, and on January 6, 1994 bermudagrass ground cover following the Roundup and tillage fallow treatments and Sinbar or atrazine after planting was no more than 4%, but was 78% following the Oust fallow treatment followed by Sinbar after planting.

Roundup Plus Additives. Bermudagrass control 28 DAT was at least 80% for all Roundup treatments except Roundup plus Herbimax (64%). Ground cover rating were made in May 1993

to determine the long-term effects of the Roundup treatments. Compared with the standard treatment of Roundup alone, bermudagrass ground cover was significantly greater when Roundup was applied with Herbimax, Herbimax plus ACA, and Roundup plus Agridex plus Buffer PS applied in pH 9 water (32 - 44% vs. 13% ground cover). Bermudagrass ground cover in the untreated check was 78%.

Bermudagrass Control in Succession Planted Cane. Bermudagrass control on February 25, 1994 was at least 87% when Oust either alone or in combination with Sencor or Sinbar was applied in December after sugarcane was succession planted on December 16, 1993. In comparison, Sencor, Sinbar, and atrazine controlled bermudagrass 51, 66, and 39%. Cane injury could not be determined since few plants were emerged on February 25.

Vaseygrass Research:

This weed has become a major problem in some areas. Herbicide treatments were applied May 6 when vaseygrass was 10 to 44 inches tall. Vaseygrass control on June 14 was 84% with the Asulox (4 quarts/A) plus Agridex standard. Addition of 2 or 4 ounces/A of Roundup to Asulox did not increase vaseygrass control over that of Asulox alone, but did increase sugarcane injury (23 vs. 14%). Oust at 3.5 and 7 grams/A controlled vaseygrass no more than 46% and injured sugarcane 61%. Asulox plus Oust controlled vaseygrass 90% or more but was too injurious to sugarcane. Early season sugarcane injury associated with the Oust treatments was reflected in reduced stalk heights and millable stalk populations.

Research is underway to evaluate Oust as a fallow and after-planting treatment compared with standard treatments for vaseygrass control. Research will be initiated in spring to compare standard herbicides in conjunction with shaving to manage this weed.

Ryegrass Research:

Questions have arisen concerning the effect of ryegrass on sugarcane growth in spring. Previous research has shown excellent control with low rates of Sencor/Lexone when applied to 3 to 4 leaf ryegrass in December. Research is underway to evaluate Sencor/Lexone applied later and to evaluate the potential for use of Gramoxone Extra (paraquat) in January and February. Mid-January application of Gramoxone Extra at 1.5 or 2 pts/A plus Agridex provided excellent ryegrass control. Addition of atrazine or Karmex to Gramoxone Extra enhanced ryegrass control when application was delayed until mid-February. Gramoxone Extra applied as a winter treatment prior to sugarcane greenup offers an excellent means to control not only ryegrass but also winter annuals that can interfere with soil contact of preemergence herbicides applied in spring. It is hoped that data collected from these studies will lead to a label change that will allow for use of Gramoxone Extra in January and February for ryegrass control.

HERBICIDE RESEARCH IN TRANSPLANTED SUGARCANE SEEDLINGS

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in cooperation with
St. Gabriel Research Station

SUMMARY:

An experiment was conducted in 1993 to test herbicides on the plant survival rate and weed control in transplanted sugarcane seedlings. The seedling plants were grown in a greenhouse from true seed and transplanted in field plots in April, 1993. Atrazine, Prowl, and Sencor herbicides were applied at a recommended rate (X) and at twice the recommended rate (2X) immediately after planting and irrigating the seedling plots. The number of dead and live plants and percent weed control were recorded on the treated plots and a check plot for several weeks after transplanting.

The results show that the Atrazine and Prowl at each rate of application did not affect the survival rate of the seedlings and gave an acceptable level of weed control. The percent weed control was better with Atrazine on broadleaf weeds and with Prowl on grass weeds. A combination of Atrazine and Prowl could possibly give a better control of all weeds. Sencor gave excellent control of all the weeds, but it caused injury to some of the seedling plants and the survival rate was not acceptable. More research is needed on Sencor and combinations of other herbicides in sugarcane seedlings.

OBJECTIVES:

The research was initiated to evaluate herbicides for a high plant survival rate and percent weed control in transplanted sugarcane seedlings.

RESULTS AND DISCUSSION:

An experiment was conducted in 1993 to test the effects of rates of Atrazine, Prowl, and Sencor herbicides on the plant survival rate and weed control in transplanted sugarcane seedlings. The test was located on a Commerce soil on the St. Gabriel Research Station. Seedling plants were grown in a greenhouse from true seed obtained from several parental crosses in the LSU Sugarcane Breeding program. The seedlings were transplanted in the field about one foot apart on one-row plots, 150 feet long in April, 1993. The seedlings were irrigated and an X rate and 2 X rate of each herbicide were applied immediately after transplanting. The X rate is the recommended rate normally used in cane production and the 2 X rate is twice the recommended rate. Normal cultural practices and irrigation as needed were applied during the growing season.

The number of dead and live seedling plants was recorded on the treated plots and a check plot two and four weeks after transplanting. Also, the percent control of grass and

broadleaf weeds was determined after four weeks. The data obtained in the experiment are reported in Table 1.

The results show that the Atrazine and Prowl herbicides at the two rates of application did not affect the survival rate of the seedlings and gave acceptable levels of weed control. The low percent of dead plants on the Atrazine, Prowl, and check plots shown in Table 1 occurs naturally every year regardless of treatment. The percent weed control was better with Atrazine on broadleaf weeds and better with Prowl on grass weeds. The control in both weed types was slightly better with the 2 X than the X rate of Atrazine and Prowl. The Sencor herbicide at each rate significantly reduced the plant population, but gave an excellent control of grass and broadleaf weeds. The seedling plant populations were reduced 25.2% with the X rate and 44.2% with the 2 X rate of Sencor. This reduction due to herbicide injury is not acceptable in a seedling program.

Generally, the preliminary results indicate that the use of a combination of Atrazine and Prowl could give a better control of all weeds than each one alone. Plant injury from Atrazine or Prowl applied after planting was not a problem, but possible injury from a combination of the two is not known. Sencor gave excellent weed control superior to the other herbicides, but it caused severe damage to the seedling population when applied after transplanting. Sencor is primarily a pre-emergence with some post-emergence effect on small weeds. Therefore, it is possible that Sencor applied prior to planting seedlings could give excellent weed control with an acceptable plant survival rate. More research is needed with Sencor and different combinations of other herbicides in the sugarcane seedling program.

Table 1. Effects of rates of herbicides on transplanted sugarcane seedlings and weed control on the St. Gabriel Research Station, 1993.

Herbicide applied	Rate Applied	Total seedling planted	Percent Seedling dead after		Percent weed control after 4 weeks	
			2 WEEKS	4 WEEKS	GRASS	BROADLEAF
	Pints/A	No./plot	%	%	%	%
Check		129	1.2	4.7	0	0
Atrazine	X - 2.0	126	1.6	2.4	70	95
	2X - 4.0	135	0.8	1.9	80	98
Prowl	X - 1.5	127	4.0	5.2	80	60
	2X - 3.0	142	1.4	1.4	90	80
Sencor	X - 1.5	127	22.9	25.2	100	98
	2X - 3.0	138	42.8	44.2	100	98
LSD .05			3.2	8.4		

X rate is the recommended rate on a 36 - inch band in normal cane production.

SOIL FERTILITY RESEARCH IN SUGARCANE IN 1993

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in cooperation with
St. Gabriel Research Station and W. B. Hallmark and
L. P. Brown at the Iberia Research Station

SUMMARY:

Five field experiments were conducted in 1993 at several locations to test the effects of rates of fertilizers on the yield of sugarcane grown on different soil types. In a P x K test plus N and S treatments on a Coteau soil, the cane and sugar yields of second stubble cane were significantly increased with 120 lbs/A of N and 100 lbs/A of K. Higher K rates and rates of P and S did not increase yield. In an N x P x K test plus fall applied NPK and S treatments on a Baldwin clay soil, the cane and sugar yields were increased with 80 lbs/A of N, but not from higher N rates. The P, K and S rates did not increase yield. Yield increases from fall applied NPK at planting time were close to significant in this test.

In an NPK fertilizer test on a Commerce soil, yields of second stubble cane from fallow and succession planted cane were increased from fall applied 15-45-45 fertilizer with N or NPK applied in the spring. In another test on Commerce soil, yields of plant cane from fallow planted cane were increased from fall applied 45-45-45 NPK fertilizer with N or NPK applied in the spring. In each test, yield differences from higher fall rates and between N and NPK treatments in the spring were small.

OBJECTIVES:

This research was designed to provide information on soil fertility in an effort to help cane growers to produce maximum economic yields and to increase profitability in sugarcane production. This annual progress report is presented to provide the latest available data on certain practices and not as a final recommendation for growers to use all of these practices. Recommendations are based on several years of research data.

RESULTS AND DISCUSSION:

Five experiments were conducted in 1993 at several locations to test the effects of rates of fertilization on the yield of fallow and succession planted sugarcane. The fallow cane was planted after a fallow year in a normal cane rotation, and the succession cane was planted immediately after harvesting a stubble cane crop without a fallow year.

This research was supported in part by grant funds from the American Sugar Cane League.

Rates of P, K, and S Fertilizers

An experiment was conducted to test rates of P, K, and S fertilizers on yield of second stubble cane on a Coteau soil on Lemaire Farms in Iberia Parish. The rates consisted of 0, 30 and 60 lbs/A of phosphate 0, 50, 100, and 150 lbs/A of potash and 24 lbs/A of sulphur. The treatments were applied in April and 120 lbs/A rate of N was applied to all the plots except the check plot. The data obtained at harvest time are reported in Table 1. The cane and sugar yields from 120 lbs/A of N and from most of the NPK treatment combinations were significantly higher than the check plot yield. A P x K factorial analysis of the yield data showed that the cane and sugar yields were significantly increased with 100 lbs/A of potash, but a higher potash rate did not improve yield. The yield increases from the phosphate rates and from 24 lbs/A of sulphur were small. The mean percent Brix and sucrose were not affected by the potash and phosphate rates.

Rates of N, P, K, and S Fertilizers

An experiment was conducted to test rates of N, P, K, and S fertilizers on yield of plant cane on a Baldwin clay soil on the Iberia Research Station. The rates consisted of 80, 160 and 240 lbs/A of N, 0 and 60 lbs/A of phosphate, and 0 and 80 lbs/A of potash in all possible combinations. In addition a fall applied 90-90-90 NPK fertilizer and 24 lbs/A rate of sulfur were tested with some of the NPK treatments. The fall fertilizer was applied in the planting furrow. The plant cane yield data obtained at harvest time are reported in Table 2. The cane yields from 80 lb/A N and from all NPK treatment combinations were significantly higher than the check plot yield. However, a factorial analysis of the data showed that the yield components were not increased from N rates above 80 lbs/A and from the phosphate and potash rates tested. The yield increase from the fall applied NPK at planting time was close to significance, especially where only N was applied in the spring. The increase from 24 lbs/A of sulphur was small. It is anticipated that the yield responses to the fertilizer treatments in this test will be larger in stubble cane next year.

Fertilizer Rates in Fallow and Succession Cane

An experiment was initiated to test the effects of NPK fertilizer rates applied in the fall and spring in fallow and succession planted cane. The fallow cane was planted after a fallow year and the succession cane was planted immediately after harvesting a cane crop without a fallow year in 1990. The fall applied NPK rates tested were 0-0-0, 15-45-45, 45-45-45, and 90-90-90. Spring applied rates of 120-0-0 and 120-40-80 were tested with each fall rate. Also, Furadan at 10 lbs/A applied in the fall and spring was tested in the succession cane. The fall treatments were applied in the planting furrows in 1990 and spring treatments were applied in the off-bar furrows in the plant cane and first and second stubble crops. The second stubble yield data obtained in 1993 from the fallow planted part of the experiment are reported in Table 3.

The results showed that N and NPK spring treatments without fall fertilizer increased the cane and sugar yields, stalk number and weight and the juice quality. The mean effect data show that the cane and sugar yields were increased from the fall applied 15-45-45 fertilizer with N and NPK applied in the spring. Higher fall rates did not improve yields. The average

differences in yield components between the N and NPK spring rates were small. The most profitable yield in this second stubble cane from planting after a fallow year was produced with 15-45-45 fertilizer applied at planting time and 120 lbs/A of N applied in spring.

The second stubble yield data obtained in 1993 from the succession cane part of the test are reported in Table 4. As in the fallow planted cane, the N and NPK spring treatments without fall applied fertilizer increased all the yield components in succession planted second stubble cane. The cane and sugar yields were increased from fall applied 15-45-45 fertilizer with N or NPK applied in spring. The differences in yield among fall rates and between spring N and NPK rates were small. The Furadan treatment did not affect yield this year. The highest yield in second stubble from succession planting was produced with 15-45-45 applied at planting time and 120 lbs/A of N applied in the spring.

The average sugar yield per acre from all the fertilizer treatments in this second stubble test was 9.9% less in succession cane than in fallow planted cane. However, the sugar yields were essentially the same in succession cane (6860 lbs/A) and in fallow cane (6800 lbs/A) where the succession cane was treated with a fall applied 15-45-45 NPK fertilizer plus 120 lbs/A of N in the spring and the fallow cane was treated with the recommended 120-40-80 in the spring. The fall applied NPK at planting time with N applied each spring is more economical than the recommended NPK each spring. This shows that succession cane can produce similar yields to fallow cane with fall fertilization at planting time.

A new experiment was planted to test the effects of NPK fertilizer rates applied in the fall and spring in fallow and succession planted cane in 1993. The fall applied rates tested were 0-0-0, 45-45-45, and 90-90-90. The spring applied rates were the same as described in the above test. The fallow and succession planted cane was planted with Variety LCP 82-089 on the same day in late October, 1992. The plant cane stands in spring, 1993 were poor and not uniform mostly in the succession cane for some unknown reason. Therefore, the plant cane yield data from only the fallow planted cane are reported in Table 5. The results showed that large increases were obtained in cane and sugar yields of plant cane planted after a fallow year from applying a 45-45-45 NPK fertilizer at planting time. These increases were produced with N and NPK applied in the spring. However, the differences in yield between the N and NPK treatments in spring were small. Apparently, Variety LCP 82-089 produces poor and erratic cane stands in the spring when it is planted late in the planting season. Therefore, this variety should not be used for planting succession cane.

Table 1. Effect of rate of fertilizer application on the yield of second stubble cane on Coteau silt loam on Lemaire Farms In Iberia Parish, 1993.

Fertilizer applied $N-P_2O_5-K_2O$	Stubble cane yield	Stalk		Normal Juice		Sugar yield
		No.	Wt.	Brix	Sucrose	
lbs/A	T/A	1000/A	lbs.	%	%	lbs/A
0-0-0	21.5	22.4	1.85	15.5	12.8	3828
120-0-0	24.5	26.8	2.07	16.2	13.3	4647
120-0-50	26.4	26.3	2.08	15.9	13.1	4862
120-0-100	27.2	24.2	2.34	16.1	13.3	5136
120-0-150	26.4	27.0	2.34	16.4	13.9	5201
120-30-0	23.2	23.7	1.97	16.0	13.1	4250
120-30-50	24.0	26.5	2.23	16.4	13.9	4754
120-30-100	27.1	28.5	2.08	15.6	12.9	4885
120-30-150	29.9	28.3	2.22	16.0	13.4	5638
120-60-0	24.9	26.9	2.04	16.5	13.6	4797
120-60-50	27.4	27.6	2.02	16.7	14.0	5411
120-60-100	27.6	27.5	2.14	16.2	13.4	5243
120-60-150	29.1	26.2	2.08	16.0	13.4	5509
120-60-150 + 24S	28.9	27.0	2.13	16.0	13.2	5378
LSD .05	2.8	3.9	0.37	1.0	1.3	816

A PXK factorial analysis of the data showed that the cane and sugar yields were significantly increased with the K rates, but not with the P rates.

This experiment was conducted in cooperation with W. B. Hallmark and L. P. Brown at the Iberia Research Station.

Table 2. Effect of rate of fertilizer application on the yield of plant cane on a Baldwin clay soil on the Iberia Research Station in Iberia Parish, 1993.

Fertilizer applied $N-P_2O_5-K_2O$	Plant cane yield	Stalk weight	Normal juice		Sugar yield
			Brix	Sucrose	
lbs/A	T/A	lbs.	%	%	lbs/A
0-0-0	27.0	2.51	17.2	14.8	5754
80-0-0	32.9	2.80	17.5	15.1	7180
80-60-0	31.2	2.51	17.1	14.8	6636
80-0-80	32.5	2.62	17.7	15.3	7176
80-60-80	32.6	2.61	17.3	15.0	7053
160-0-0	31.1	2.79	17.3	15.1	6810
160-0-0 + Fall NPK	34.0	2.88	17.0	14.6	7099
160-60-0	32.3	2.69	17.6	15.3	7155
160-0-80	33.2	2.78	17.1	14.7	7035
160-60-80	33.5	2.77	17.0	14.8	7124
160-60-80 + 24S	33.7	2.64	17.4	15.0	7313
160-60-80 + Fall NPK	34.1	2.54	16.9	14.5	7078
240-0-0	31.0	2.68	17.5	15.2	6812
240-60-0	33.9	2.53	17.5	15.1	7352
240-0-80	30.8	2.28	17.0	14.6	6440
240-60-80	30.0	2.37	17.3	14.7	6309
LSD .05	3.1	0.27	0.5	0.5	710

Fall NPK = 90-90-90 lbs/A applied at planting time.
24S = 24 lbs/A of sulphur
This experiment was conducted in cooperation with W. B. Hallmark and L. P. Brown at the Iberia Research Station.

Table 3. Effect of rate of fall and spring applied fertilizers on yield of second stubble cane planted after a fallow year on a Commerce silt loam soil on the St. Gabriel Research Station, 1993.

Fertilizer Applied $N-P_2O_5-K_2O$		Stubble cane yield	Stalk		Normal juice		Sugar yield
Fall	Spring		No.	Wt.	Brix	Sucrose	
lbs/A	lbs/A	T/A	1000/A	lbs	%	%	lbs/A
				Fallow planted cane			
0-0-0	0-0-0	21.3	28.4	1.83	15.0	12.4	3688
	120-0-0	34.3	39.2	2.22	16.6	14.2	6977
	120-40-80	34.5	38.0	2.17	16.2	13.8	6800
15-45-45	120-0-0	38.5	38.6	2.24	16.6	14.2	7771
	120-40-80	37.9	41.0	2.16	17.3	14.9	8157
45-45-45	120-0-0	35.7	39.7	2.21	16.6	14.1	7208
	120-40-80	36.0	39.3	2.36	16.1	13.6	6943
90-90-90	120-0-0	32.0	38.2	2.31	16.0	13.3	6058
	120-40-80	32.0	39.6	2.02	17.0	14.5	6663
LSD .05 Treatments		3.2	3.1	0.32	1.2	1.4	927
				Mean effects			
0-0-0		34.4	38.6	2.19	16.4	14.0	6889
15-45-45		38.2	39.8	2.20	16.9	14.6	7964
45-45-45		35.8	39.5	2.29	16.4	13.9	7075
90-90-90		32.0	38.9	2.16	16.5	13.9	6361
	120-0-0	35.1	39.0	2.24	16.5	14.0	7003
	120-40-80	35.1	39.5	2.18	16.6	14.2	7141
LSD .05 Fall means		2.1	NS	NS	NS	NS	649
LSD .05 Spring means		NS	NS	NS	NS	NS	NS

Variety CP 70-321 was planted after a fallow year. The fall fertilizer was applied in planting furrows and the spring fertilizer was applied in off-bar furrows.

Table 4. Effect of rate of fall and spring applied fertilizers on yield of second stubble cane planted in succession on a Commerce silt loam soil on the St. Gabriel Research Station, 1993.

Fertilizer Applied N-P_2O_5-K_2O		Stubble cane yield	Stalk		Normal juice		Sugar yield
Fall	Spring		No.	Wt.	Brix	Sucrose	
lbs/A	lbs/A	T/A	1000/A	lbs	%	%	lbs/A
		Succession planted cane					
0-0-0	0-0-0	23.4	29.3	1.83	15.5	13.0	4249
	120-0-0	28.4	31.6	2.13	17.0	14.5	5902
	120-40-80	29.5	32.6	2.12	16.7	14.4	6089
	120-40-80 + F	30.7	33.4	2.18	16.7	14.2	6204
15-45-45	120-0-0	32.0	32.7	2.19	17.3	14.9	6860
	120-40-80	31.2	32.4	2.16	17.2	14.8	6623
	120-40-80 + F	30.2	34.0	2.17	17.0	14.5	6257
45-45-45	120-0-0	27.8	34.4	2.01	16.9	14.3	5704
	120-40-80	27.6	35.3	2.13	16.9	14.4	5706
	120-40-80 + F	28.6	36.2	2.17	17.1	14.6	5972
90-90-90	120-0-0	29.7	36.4	2.07	17.3	14.8	6340
	120-40-80	30.9	37.1	2.05	17.1	14.6	6462
	120-40-80 + F	28.8	36.0	1.87	17.0	14.6	6066
LSD .05 Treatments		2.6	2.7	0.28	1.0	1.0	822
		Mean effects					
0-0-0		29.5	32.6	2.14	16.8	14.4	6065
15-45-45		31.1	33.0	2.17	17.2	14.7	6580
45-45-45		28.0	35.3	2.10	17.0	14.4	5794
90-90-90		29.9	36.5	2.00	17.1	14.7	6290
	120-0-0	29.5	33.8	2.10	17.1	14.6	6202
	120-40-80	29.8	34.4	2.11	17.0	14.5	6220
	120-40-80 + F	29.6	34.9	2.10	16.9	14.5	6125
LSD .05 Fall means		1.5	1.6	NS	NS	NS	494
LSD .05 SPRING MEANS		NS	NS	NS	NS	NS	NS

Variety CP 70-321 was planted in succession following a stubble crop. The fall fertilizer was applied in planting furrows and the spring fertilizer was applied in off-bar furrows.
F = Furadan at 10 lbs/A applied in fall and spring.

Table 5. Effect of rate of fall and spring applied fertilizers on yield of plant cane planted after a fallow year on Commerce soil on the St. Gabriel Research Station, 1993.

Fertilizer Applied $N-P_2O_5-K_2O$		Plant cane yield	Stalk		Normal juice		Sugar yield
Fall	Spring		No.	Wt.	Brix	Sucrose	
lbs/A	lbs/A	T/A	1000/A	lbs	%	%	lbs/A
				Fallow planted cane			
0-0-0	120-0-0	22.9	25.2	2.31	17.6	14.4	4730
	120-40-80	21.7	23.1	2.14	17.3	14.4	4468
45-45-45	120-0-0	32.2	33.3	2.37	17.8	15.0	6971
	120-40-80	32.1	32.1	2.28	17.7	14.9	6855
90-90-90	120-0-0	21.4	23.9	2.44	17.9	15.0	4622
	120-40-80	26.4	25.3	2.37	17.0	14.0	5291
LSD .05 Treatments		3.7	4.6	NS	0.9	NS	1061
				Mean Effects			
0-0-0		22.3	24.2	2.23	17.5	14.4	4599
45-45-45		32.2	32.7	2.33	17.8	14.9	6913
90-90-90		23.9	24.6	2.41	17.5	14.5	4956
	120-0-0	25.5	27.5	2.37	17.8	14.8	5441
	120-40-80	26.7	26.9	2.27	17.3	14.4	5538
LSD .05 Fall means		2.6	3.3	NS	NS	NS	750
LSD .05 Spring means		NS	NS	NS	NS	NS	NS

Variety LCP 82-089 was planted after a fallow year. The fall fertilizer was applied in the planting furrows and the spring fertilizer was applied in the off-bar furrows.

EFFECT OF NITROGEN AND CALCIUM CHLORIDE ON SUGARCANE YIELD PARAMETERS

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Summary:

The effects of liquid urea (0, 60, 120, and 180 lbs N/A) and calcium chloride (0, 20, and 40 lbs Ca/A as N-hib Ca supplied by Stoller Chemical Company) were tested on second stubble sugarcane yield parameters.

Unlike in 1992 with first stubble, calcium did not increase cane tonnage or sugar yield in 1993 with second stubble cane. Nitrogen application, however, did progressively increase cane stalk weight, plant population, cane tonnage, and sugar yield up to the 120 lbs N/A rate, but had no further effect with 180 lbs N/A.

Introduction:

Sugarcane production in Louisiana is limited by the relatively rapid deterioration in stubble crop yields. This results in the expensive practice of replanting every third or fourth year. Also, stubble crops require higher fertilizer rates than plant cane, while producing less cane per acre.

The decrease in cane yields and increased fertilizer needs of stubble crops are thought to be related to the deterioration of the sugarcane root system. Consequently, if cultural practices could be identified that reduce, or delay, the deterioration of the sugarcane root system, it should be possible to increase fertilizer use efficiency and yields.

Research with other crops indicates that adding calcium chloride to liquid urea in a soil fertilization program can increase yields. Thus far, however, the effects of calcium chloride on sugarcane yields have not been determined.

Objectives of our study were to:

1) Determine whether calcium chloride can increase sugarcane yields.

2) Determine whether calcium chloride can reduce the N fertilizer requirements of sugarcane.

Procedures:

In October of 1990, a urea x calcium chloride soil fertility study was initiated at the Iberia Research Station on a Baldwin silty clay soil. The experiment consisted of the twelve treatments given in Table 2, replicated three times in a randomized complete block design. Experimental plots consisted of three 5'10" by 48' rows, separated by 8' alleys at the ends of

the plots.

In late October of 1990, the sugarcane rows were opened and variety CP65-357 was planted at three stalks and a lap of two joints. The rows were then closed to allow the sugarcane to germinate.

In early May of 1993, liquid urea and liquid calcium chloride were added to the right off-bar at the N and Ca rates given in Table 2. Phosphorus K and S were blanket applied to the left off-bar of all rows in the study at 60 lbs P_2O_5, 80 lbs K_2O, and 24 lbs S/A. The rows were "hipped-up" to cover the fertilizer in the off-bar, and the cane was then grown till harvest using standard cultural practices.

In September of 1993 sugarcane stalks in all plots were counted to determine the effects of the treatments on plant population. The plots were than harvested in November and weighed with a weigh rig. A 10 stalk sample was taken from each plot to determine average stalk weight and juice quality.

Results and Discussion:

Tables 1-4 shows the effect of liquid urea (N) and liquid calcium chloride (Ca) on second stubble yield parameters in 1993. Nitrogen affected ($P \leq 0.10$) stalk weight, plant population, cane yield and sugar/A (Table 1). Calcium did not affect ($P \leq 0.25$) any of the yield parameters. Since the N x Ca interactions for the variables were all nonsignificant (Table 1), LSD values are not given in Table 2.

Table 3 shows that nitrogen fertilization progressively increased stalk weight, plant population, cane yield, and sugar/A up to 120 lbs N/A, but then had no further effect with 180 lbs N/A.

Table 1. F-values for yield parameters for a second stubble nitrogen x calcium study on a Baldwin silty clay soil at the Iberia Research Station in 1993.

Source	df	Stalk wt.	Population	CRS	Cane Yield	Sugar Yield
Nitrogen (N)	3	2.98▮	14.29****	0.63	30.76****	33.60****
Calcium (Ca)	2	0.02	0.19	0.17	0.94	0.56
NxCa	6	0.39	0.73	0.21	0.84	0.97
% CV		12.66	8.93	6.99	9.75	9.84
RMSE		0.2267	2516	12.84	2.799	519.4

▮ and **** denote statistical significance at the P≤0.10 and 0.0001 levels, respectively. Remaining F-values were nonsignificant at P≤0.25.

Table 2. Effect of nitrogen and calcium chloride on second stubble yield parameters at Jeanerette in 1993.

T#	N†	Ca†	Stalk wt.	Population	CRS	Cane yield	Sugar yield
	- lbs/A -		lbs	1000/A	lbs/T	T/A	lbs/A
1	0	0	1.52	23.9	184	21.3	3,920
2	0	20	1.64	23.5	179	21.7	3,880
3	0	40	1.65	23.2	179	20.9	3,750
4	60	0	1.86	29.1	181	29.1	5,260
5	60	20	1.88	29.6	186	29.3	5,430
6	60	40	1.70	27.8	181	28.9	5,200
7	120	0	1.90	29.1	185	31.3	5,770
8	120	20	1.90	29.7	190	30.1	5,650
9	120	40	1.89	32.1	191	34.1	6,510
10	180	0	1.91	29.9	180	34.3	6,190
11	180	20	1.77	31.3	188	30.2	5,680
12	180	40	1.88	28.9	182	33.4	6,080
LSD 0.10			NA	NA	NS	NA	NA
LSD 0.25			NA	NA	NS	NA	NA

† Nitrogen was applied as liquid urea.
† Calcium was applied as liquid calcium chloride with the liquid urea.
NA Denotes that the LSD values are not given because the NxCa interaction was nonsignificant at P≤0.25.
NS Denotes that the indicated variables were not affected at the P≤0.25 level.

Table 3. Effect of nitrogen on second stubble yield parameters at Jeanerette in 1993.

N	Stalk wt.	Population	CRS	Cane yield	Sugar yield
lbs/A	lbs	1000/A	lbs/T	T/A	lbs/A
0	1.60	23.5	180	21.3	3,850
60	1.81	28.8	183	29.1	5,300
120	1.90	30.3	188	31.8	5,980
180	1.85	30.0	183	32.7	5,980
LSD 0.10	0.18	2.0	NS	2.3	420
LSD 0.25	0.13	1.4	NS	1.6	290

NS Denotes that nitrogen fertilization did not affect the yield parameter at the indicated P level.

Table 4. Effect of calcium chloride on second stubble yield parameters at Jeanerette in 1993.

Ca	Stalk wt.	Population	CRS	Cane yield	Sugar yield
lbs/A	lbs	1000/A	lbs/T	T/A	lbs/A
0	1.80	28.0	183	29.0	5,280
20	1.80	28.5	185	27.8	5,160
40	1.78	28.0	183	29.3	5,380
LSD 0.10	NS	NS	NS	NS	NS
LSD 0.25	NS	NS	NS	NS	NS

NS Denotes that the variables was not affected by calcium chloride at the indicated P levels.

EFFECT OF NITROGEN, PHOSPHORUS, POTASSIUM, AND SULFUR FERTILIZER ON SUGARCANE YIELDS

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Summary:

The effects of N, P, K, and S fertilization on second stubble sugarcane yields on a Jeanerette silt loam, and plant cane yields on a Baldwin silty clay were determined in 1993.

Nitrogen increased ($P \leq 0.10$) cane 7.5 T/A and sugar 1410 lbs/A on the Jeanerette soil. Potassium increased cane 7.0 T/A and sugar 1180 lbs/A; and P increased tonnage 3.6 T/A and sugar 770 lbs/A. Sulfur fertilization had no effect on any of the yield parameters.

On the Baldwin silty clay soil nitrogen increased cane yields 6.7 T/A and sugar yields 1390 lbs/A. Spring fertilization with P, K, and S did not affect either cane tonnage or sugar/A. Fall fertilization with N, P, and K under cane at planting increased cane yields 3.0 T/A where P and K were not applied in the spring of 1993.

Procedures:

In 1991 a N, P, K, and S soil fertility study was initiated on a Jeanerette silt loam soil with Mr. Fabian LeMaire near Jeanerette. First progeny Kleentek variety CP70-321 was planted at two stalks and a lap of two joints in September, 1990. All plots consisted of four 5'10" by 36' rows with 8' alleys separating the plots. Fertilizer treatments (Table 2) were replicated three times in a randomized complete block design. Fertilizer treatments were applied in the off-bar in April of 1993.

A second N, P, K, and S soil fertility study was initiated on a Baldwin silty clay soil at the Iberia Research Station. Kleentek variety CP70-321 was planted at three stalks and a lap of two joints in September 1992. The experimental design was a randomized complete block with four replications. Plots consisted of three 5'10" by 58' rows with 8' alleys separating the plots. All fertilizer treatments (Table 4) were applied in April, 1993 in the off-bar, except the fall fertilizer in T#'s 15 and 16 which was applied under the cane at planting.

In September of 1993, sugarcane stalks, from both studies, were counted to determine the effects of the treatments on plant population. The plots were then harvested in November and December of 1993 and weighed with a weigh rig. A 10-stalk sample was taken from each plot to determine average stalk weights and juice quality.

Results and Discussion:

Tables 1 and 2 show the effect of N, P, K, and S fertilizer on second stubble yield parameters in 1993 on a Jeanerette silt loam soil. Fertilizer treatments significantly affected cane and sugar yields and there was a trend ($P \leq 0.25$) for the fertilizer to affect plant population.

Table 2 shows that K significantly ($P \leq 0.10$) increased cane tonnage (T#'s 7 vs. 5 and 11 vs. 9) where P was added, but not where it was not added. There was also a trend ($P \leq 0.25$) toward higher yields with K addition to T #9.

Phosphorus application did not significantly increase cane tonnage or sugar/A for any of the treatments, except T #4 where 150 lbs/A of K_20 had been added.

Sulfur application (T#'s 14 vs. 12) had no significant effect on plant population, tonnage or sugar yield (Table 2); however, N fertilization (T #13 vs. 1) increased ($P \leq 0.10$) all three of these variables. Using the recommended fertilizer rate (T #11) resulted in increased cane tonnage and sugar yield 10.4 T/A and 2,370 lbs/A, respectively, over the unfertilized check (T #13).

Tables 3 and 4 show the effect of N, P, K, and S fertilizer on plant cane yield measurements on a Baldwin silty clay soil in 1993. Fertilizer application significantly ($P \leq 0.10$) affected stalk weight, CRS, tonnage, and sugar yield, but not plant population (Table 3).

Applying N, P, and K to T #6 under cane at planting had no effect ($P \leq 0.10$) on stalk weight and sugar/A, but did decrease CRS and increased cane tonnage (Table 4). Fall applying N, P, and K to T #9 decreased stalk weight, but had no effect ($P \leq 0.10$) on CRS, cane tonnage, or sugar/A.

Applying N increased ($P \leq 0.10$) stalk weights of T#'s 1 but decreased stalk weights for T#'s 8 and 9. Nitrogen increased CRS for T #3, but decreased it for T #4. Nitrogen also increased cane tonnage and sugar yield for T #1, and sugar/A for T #3, but decreased cane tonnage and sugar/A for T #9.

Phosphorus fertilizer decreased stalk weights of T #2, but had no effect on any of the other treatments. Phosphorus increased cane tonnage of T #11 but had no effect on tons/A or sugar/A for any of the other treatments.

Potassium application decreased ($P \leq 0.10$) CRS for T#'s 6, 7, 11, and 12. Potassium also decreased cane tonnage for T #12 and sugar/A for T #9. Sulfur fertilization didn't affect any of the measured yield parameters.

Table 1. F-values for effect of fertilizer on second stubble yield parameters for a Jeanerette silt loam soil at Jeanerette in 1993.

Source	df	Stalk wt.	Population	CRS	Cane yield	Sugar yield
Treatments	15	1.13	1.67°	0.82	4.96***	4.19***
% CV		10.36	8.93	6.30	8.98	10.63
RMSE		0.2189	2417	11.73	2.425	534.5

° and *** denote statistical significance at the $P \leq 0.25$ and 0.001 levels, respectively. Remaining F-values were non- significant at the $P \leq 0.25$ level.

From: Effect of Nitrogen, Phosphorus, Potassium, and Sulfur Fertilizer on Sugarcane Yields.

Table 2. Effect of fertilizer on second stubble yield parameters for a Jeanerette silt loam soil in 1993.

T#	N	P_2O_5	K_2O	S	Millable Stalk Wt.	Millable Stalk No.	CRS	Cane yield	Sugar yield
		lbs/A			lbs	1000/A	lbs/T	T/A	lbs/A
1	120	0	0	0	2.07	27.6	180	25.9	4660
2	120	0	50	0	2.08	27.1	181	27.5	4980
3	120	0	100	0	2.34	24.8	181	28.4	5160
4	120	0	150	0	2.34	27.7	182	27.6	5030
5	120	30	0	0	1.97	24.3	190	24.2	4620
6	120	30	50	0	2.23	26.9	194	25.1	4870
7	120	30	100	0	2.08	29.3	197	28.3	5580
8	120	30	150	0	2.22	29.1	187	31.2	5800
9	120	60	0	0	2.04	27.7	184	26.0	4780
10	120	60	50	0	2.02	28.4	190	28.3	5370
11	120	60	100	0	2.14	28.4	196	28.8	5620
12	120	60	150	0	2.08	26.9	183	28.4	5160
13	0	0	0	0	1.85	23.1	180	18.4	3250
14	120	60	140	24	2.13	27.8	182	30.1	5490
LSD 0.10					NS	NS	NS	3.4	740
LSD 0.25					NS	2.3	NS	2.3	510

NS Denotes that the treatment means were not different at the indicated P levels.

From: Effect of Nitrogen, Phosporus, Potassium, and Sulfur Fertilizer n Sugarcane Yields.

Table 3. F-values for effect of fertilizer on plant cane yield parameters for a Baldwin silty clay soil at the Iberia Research Station.

Source	df	Stalk wt.	Population	CRS	Cane yield	Sugar yield
Treatments	15	2.22*	0.63	1.96*	2.93**	2.76**
% CV		7.14	5.42	2.97	6.76	7.34
RMSE		0.1883	1286	6.301	2.229	513.4

* and ** denote statistical significance at the $P \leq 0.05$ and 0.01 levels, respectively. The remaining F-value was nonsignificant at $P \leq 0.25$.

From: Effect of Nitrogen, Phosporus, Potassium, and Sulfur Fertilizer on Sugarcane Yields.

Table 4. Effect of fertilizer on plant cane yield parameters at the Iberia Research Station in 1993.

	Spring Applied				Fall applied			Millable Stalk				
T#	N	P_2O_5	K_2O	S	N	P_2O_5	K_2O	Wt.	No.	CRS	Cane yield	Sugar yield
				lbs/A				lbs	1000/A	lbs/T	T/A	lbs/A
1	0	0	0	0	0	0	0	2.51	24.4	210	27.8	5840
2	80	0	0	0	0	0	0	2.80	24.6	215	33.8	7290
3	80	60	0	0	0	0	0	2.51	23.9	210	32.1	6740
4	80	0	80	0	0	0	0	2.62	23.5	218	33.4	7300
5	80	60	80	0	0	0	0	2.61	23.4	214	33.5	7150
6	160	0	0	0	0	0	0	2.80	23.1	216	32.0	6920
7	160	60	0	0	0	0	0	2.69	24.3	219	33.3	7270
8	160	0	80	0	0	0	0	2.78	23.3	209	34.2	7140
9	160	60	80	0	0	0	0	2.77	23.6	210	34.5	7230
10	160	60	80	24	0	0	0	2.64	23.0	214	34.7	7430
11	240	0	0	0	0	0	0	2.68	23.3	217	32.0	6920
12	240	60	0	0	0	0	0	2.53	24.4	215	34.8	7430
13	240	0	80	0	0	0	0	2.49	23.9	206	31.6	6540
14	240	60	80	0	0	0	0	2.37	23.9	208	30.8	6410
15	160	0	0	0	90	90	90	2.88	23.9	206	35.0	7210
16	160	60	80	0	90	90	90	2.54	23.3	205	35.0	7190
LSD 0.10								0.22	NS	7	2.7	620
LSD 0.25								0.16	NS	5	1.9	430

NS Denotes that the treatment means were not significantly different at the indicated P levels.

UPTAKE OF NITROGEN FROM SOYBEAN RESIDUES BY SUGARCANE
(Plantcane Response)

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Summary:

The relative nitrogen uptake by sugarcane from soybean residues and indigenous soil organic N is largely unknown. An experiment was conducted on a silt loam to determine sugarcane response to incorporated soybean residues and/or applied N fertilizer. Prior to spring fertilization mean soil nitrate contents following soybeans and fallow were 10.5 and 5.9 ppm, respectively, for the 1 ft depth of sampling. At the grand growth stage in August, highest nitrate levels were found in plots benefitting from both fertilizer and soybean residue. These nitrate levels are representative of levels measured in other studies in the humid south, but are considerably lower than levels measured elsewhere in the country. In spite of higher cane nitrogen percentage following soybeans, sugar and cane yields were 556 pounds of sugar/acre and 3.5 tons of cane/acre higher, respectively, for the cane following the conventional fallow sequence. Sufficient **circumstantial** evidence exist to suggest that the experiment was compromised by abnormally high populations of parasitic nematodes.

Introduction:

Crop sequences involving soybeans as either a cash crop or a green manure crop are widely used in parts of the U.S. Inclusion of a legume improves soil physical properties and increases soil N availability. Little is known of the N response of sugarcane cropped after soybeans. The amount of N mineralized from soybean residues for uptake by sugarcane has not been measured in our environment. The objective of this study was to compare soybean residues and fallow as sources of N for sugarcane nutrition on a relatively low organic matter soil.

Experimental Procedures:

The experiment was conducted on a Jeanerette silt loam low in P and K, with a relatively low organic matter content of 1.1%. Treatments were a conventional fallow and sugarcane rotation grown with 0 and 130 lb N per acre, and soybean rotated with sugarcane with 0 and 120 lb N per acre applied to sugarcane. The experimental design was a randomized complete block with three replications. Plots were eight rows, 200 ft long and 68 in wide. Soybean cultivar Riverside 499 (Group IV maturity) and sugarcane variety CP 70-321 were planted on May 5, 1992 and October 5, 1992. Phosphorus and potassium fertilization and preemergence weed control were accomplished in a conventional manner according to recommended practices. Fertilizer (32% liquid N formulation) was applied on April 1, 1993.

To determine the amounts of nitrate and exchangeable ammonium in soil profiles, duplicate soil samples for each plot were taken to a depth of 5 ft, 4 ft and 1 ft, respectively, in

Research was supported by the American Sugar Cane League.

April, 1992, February, 1993 and August, 1993. Cores were in 6 in increments for the first 1 ft and 1 ft increments for the remaining depths. Composite soil samples from each depth increment were prepared by thoroughly mixing soil from the duplicate cores from each plot. Soil was dried at 30 to 35 degrees C in a forced-draft dryer and ground to pass a 1-mm screen.

Total N concentrations in whole plant sugarcane plant tissue were determined by micro-Kjeldahl. Nitrogen uptake in individual treatments was calculated from the N concentrations found in the whole plant samples and the corresponding dry matter for millable stalks and tops and leaves.

Soil samples were collected by Dr. Henry Long of Nicholls State University in March, June and December, 1993 for nematode evaluation. Plant and non-plant parasitic nematodes were counted per 100 ml of soil. Triplicate samples were taken for each plot and 3 replicate counts were determined for each sample.

Results:

Soil and cane nitrogen content were significantly affected by crop rotation (Figure no.1). Before nitrogen fertilization in March the amount of nitrate in the top 1-ft of the soil profile was greater ($P = .02$) in the soybean treatments than the fallow treatments (10.5 ppm vs 5.9 ppm). At the grand growth stage in August, plots fertilized with inorganic N contained the greater amount of nitrates in the upper soil profile (19.3 ppm for fertilized vs 3.7 ppm for unfertilized). Plots receiving both fertilizer N and incorporated soybeans contained the highest concentration of nitrates. In general, these nitrate levels are considered low relative to concentrations required for maximum yields for certain crops in other areas of the country.

Cane nitrogen content was related to soil nitrate availability, as nitrogen percentage of whole-plant above-ground cane samples was higher ($P = .04$) for cane receiving N fertilizer, .423 vs .375%. Nitrogen percentage was .401% for unfertilized cane following soybeans compared to .348% for unfertilized cane following the conventional fallow period.

Cane and sugar yields did not respond to the higher soil and plant nitrogen associated with soybean residue. Quite the contrary, yields were significantly higher following the conventional fallow period. Yields were 33.3 and 29.8 tons/acre, respectively, for cane following fallow and soybeans.

Periodically, beginning in March, 1993, soil surrounding cane roots were sampled for nematode population. It appears from the data shown in figure no. 2 that populations of parasitic nematodes were associated with depressed yield. Early spring plant parasitic nematode counts averaged 68% higher surrounding cane roots developing in soil containing soybean residues than for roots in the fallow treatments. Counts totaled over 1000 per pound of soil, a population considered economically damaging with certain other commodities. Population counts were reduced as the cane entered the grand growth stage, but differential counts remained between treatments.

Additional research is needed to establish the link between soybean residue and nematode populations and their relationship to cane production.

Figure no. 1 - Relationship of soil and plant nitrogen levels.

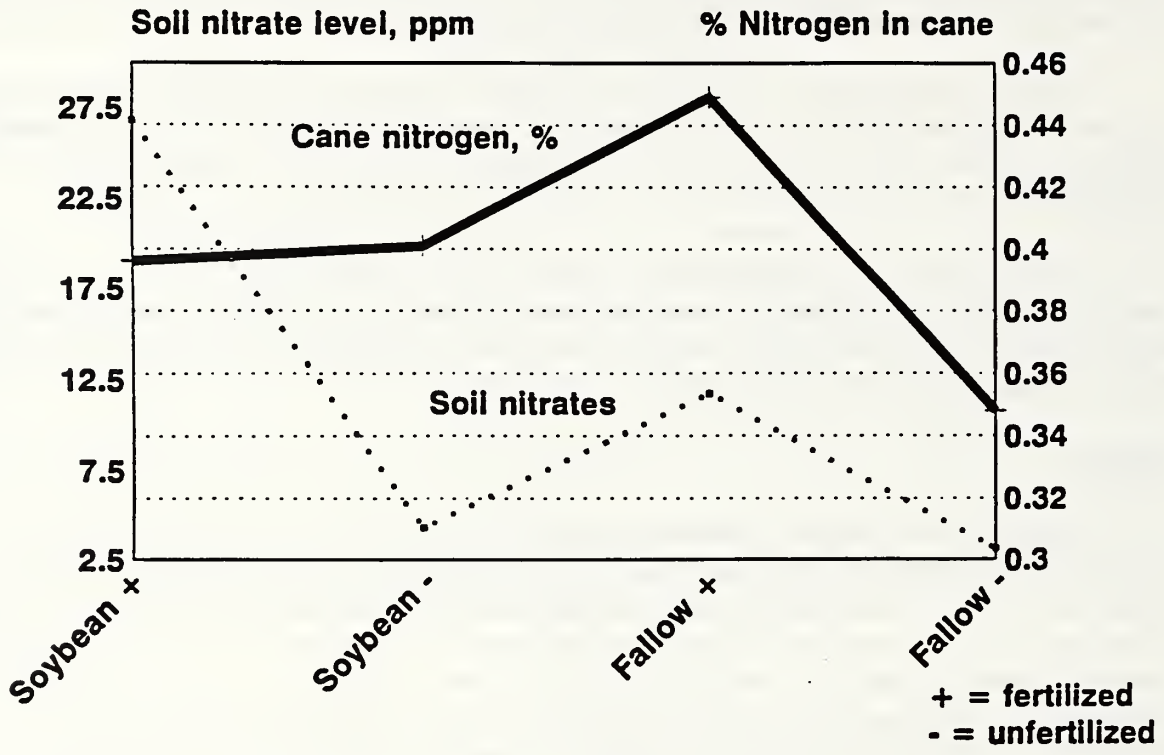
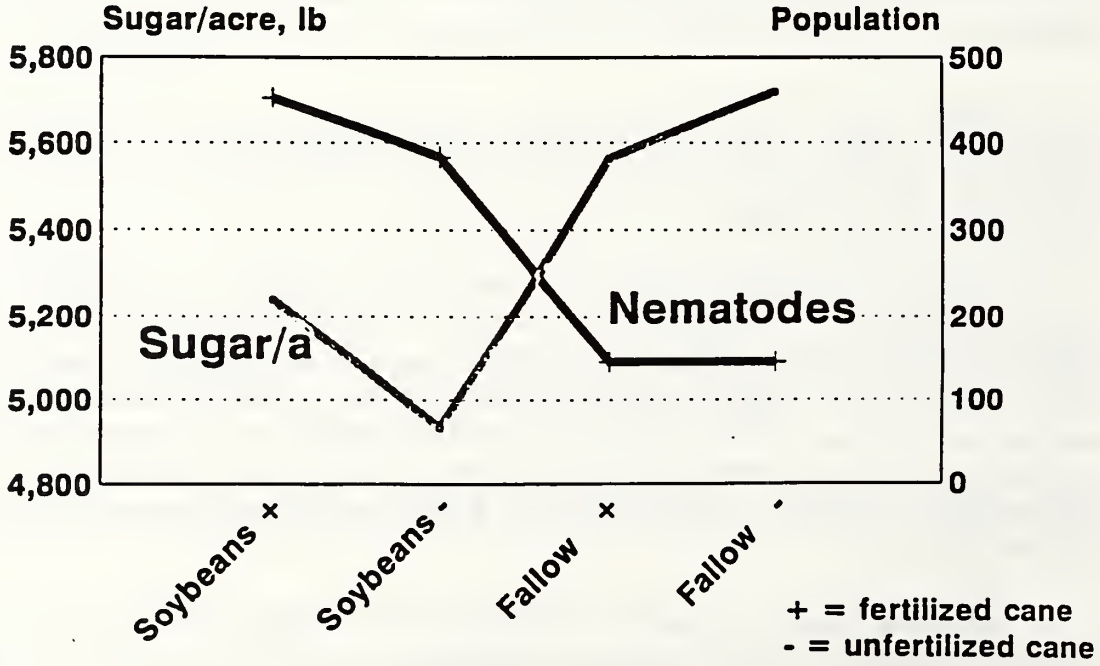


Figure no. 2 - Relationship of *Nematode* Population to Sugar Yield of Fallow-year Treatments



CULTURAL AND LAND MANAGEMENT PRACTICE RESEARCH IN SUGARCANE IN 1993

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in cooperation with the
St. Gabriel Research Station

SUMMARY:

Eleven field experiments were conducted in 1993 to test the effects of various cultural and land management practices on the yield of sugarcane. The newer cane varieties released from the breeding programs were included in the experiments. Results from tests on planting practices showed that the average cane yields of four varieties were higher in plant cane from planting in September or October than in November and in stubble cane from planting in October than the other dates. Plant cane yields were higher with a four-stalk planting rate than two- and three- stalk rates. Covering seedcane with 3-4 inches rather than 5-6 or 7-8 inches of packed soil at planting time produced less plant cane yield, but more first stubble yield.

Harvesting experiments showed that plant cane yields of four varieties increased during October and November due to increases in stalk weight and percent juice sucrose. First stubble cane yields were higher where plant cane was harvested in November and December than earlier in the season.

In stubble protection experiments, a soil cover applied over cane stubbles after harvesting increased yields of first and second stubble cane only where the cover was not removed in spring. In a stubble longevity test, the sugar yields in second stubble cane were increased 7.8% from fall applied fertilizers, 16.3% from Furadan and 11.1% from a stubble soil cover. In a stubble digger test, the use of a stubble digger, shaver and Lilliston cultivator decreased the average yields of four varieties in second stubble cane.

OBJECTIVES:

This research is designed to provide information on cultural practices in an effort to help cane growers to produce maximum economic yields and to increase profitability in sugarcane production. This annual progress report is presented to provide the latest available data on certain practices and not as a final recommendation for growers to use all of these practices. Recommendations are based on several years of research data.

RESULTS AND DISCUSSION:

Eleven field experiments were conducted in 1993 on the St. Gabriel Research Station to

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test the effects of various cultural and land management practices on the yield and yield components of sugarcane. The new cane varieties released from the breeding programs in the LAES at St. Gabriel and in the USDA at Houma were included in the experiments to determine varietal differences with the various practices.

The winter temperatures prior to the 1993 crop were close to normal except for killing freezes which occurred in November, 1992 and March, 1993. The cane and sugar yields on the experiment plots were relatively low this year due to a severe drought during the summer months and another killing freeze in November, 1993.

Date of Planting

An experiment was initiated to test the effects of planting dates on the plant cane yield of four varieties of sugarcane. The dates tested were September 1, October 1 and November 10, 1992 and the varieties were CP 70-321, LCP 82-089, LHo 83-153, and LCP 85-384. The last three varieties are newly released from the LSU Breeding Program. The data obtained are reported in Table 1. The results show that the September and October plantings produced similar cane yields, but higher than the November planting except in variety LHo 83-153. The effect of planting date on the yield of LHo 83-153 was small. As an average of varieties, the September and October planting dates produced more cane yield, stalk number and weight and sugar per acre than the November planting date. The low yields from the November date were apparently due to poor seedcane germination from planting after a mild freeze in early November.

Another test was continued in 1993 from plant cane in 1992 to test dates of planting on first stubble cane yield. The dates were September 1, October 1 and November 6 in 1991 and the varieties tested were CP 70-321, CP 72-370, CP 79-318, and LCP 82-089. The varieties were planted on each planting date in 1991 and harvested as plant cane in 1992 and first stubble cane in 1993. The data obtained in first stubble are reported in Table 2. The results show that higher yields of first stubble cane were produced from the October than September planting date in all varieties except LCP 82-089. As an average of varieties, the October date produced more yield than the September and November dates and the November date produced more than the September date of planting. The differences in yields were due to differences in stalk populations and average stalk weights.

Rate of Planting

An experiment was planted to test the effects of rates of planting on plant cane yield of new varieties LCP 82-089 and LHo 83-153 in 1993. The rates tested were two, three and four stalks planted in continuous lines in each row with a 10% overlap. The varieties were planted at each rate in September and harvested as plant cane in 1993. The data are shown in Table 3. The four-stalk rate produced more cane and sugar yields in plant cane of LHo 83-153 than the 2-stalk rate of planting. As an average, the four-stalk rate produced more cane yield than the two-stalk rate. The differences in the average sugar yields per acre due to planting rates were not significant.

Depth of Seedcane Cover

An experiment was initiated to test the effects of seed cover depth and shaving on the plant cane yield of LHo 83-153 and LCP 82-089. The rows in all plots were furrowed for planting at a normal depth and the cover depths tested were 3-4, 5-6, and 7-8 inches of packed soil. Seedcane of each variety was planted and covered with each soil depth in 1992. A shave and no shave treatments were applied to each cover depth in spring of 1993. The shave treatment left three inches of soil on all the shaved plots. The data obtained are reported in Table 4. The plant cane yields were less with the 3-4 than the 5-6 and 7-8 cover depths without shaving in LCP 82-089 and with and without shaving in LHo 83-153. The differences in yield between the 5-6 and 7-8 depths were small in each variety. The average cane and sugar yields were less with the 3-4 cover depth than the deeper depths and shaving in spring to remove excessive soil cover increased yields. The differences in yields among treatments were due to differences in stalk population and average stalk weight. The lower yield from the 3-4 inches of cover is contrary to previous results and apparently due to a killing freeze after shaving the plots in early March, 1993. Normally a 3-4 cover on seedcane is adequate for good freeze protection and good germination in the spring.

Another test was continued in 1993 from plant cane in 1992 to test seed cover depths and shaving on first stubble cane yield of varieties CP 72-370 and LCP 82-089. The same treatments were applied in plant cane in 1992 as in the above plant cane test and no treatments were applied in first stubble in 1993. The effects of the different seed cover depths on first stubble cane yield are reported in Table 5. The stubble yields were higher with the 3-4 and 5-6 depths than the 7-8 depth with and without shaving in CP 72-370. The yields were higher with the 3-4 than 5-6 depths without shaving in LCP 82-089. The average cane and sugar yields were higher with the 3-4 and 5-6 depths than the deeper depth. Shaving in the spring to remove the excessive soil cover did not improve yields.

Date of Harvest

Experiments were conducted in 1993 to test the effects of different harvest dates in plant cane of the newer varieties on the yield of plant cane and the subsequent stubble crop the following year. One test was initiated to measure the effects of harvest dates in plant cane in 1992 and the first stubble in 1993. Varieties CP 70-321, LCP 82-089, LHo 83-153, and LCP 85-384 were harvested on September 1, October 1, November 10, and December 1 in 1992. The effects of the plant cane harvest dates on first stubble yield in 1993 are reported in Table 6. The results show that the November and December plant cane harvest dates produced more first stubble yield than the September date in each variety except LCP 85-384. The December date produced more than the October date in CP 70-321 and LCP 82-089. Variety LCP 85-384 produced the highest stubble yields and was less affected by the plant cane harvest dates. As an average of varieties, the first stubble cane yield progressively increased from the September to December date of plant cane harvest. This shows the importance of harvesting a plant cane crop late in the season to produce maximum yields of first stubble yield in the following year.

Another test was conducted to measure the effects of harvest dates in plant cane on yield of plant cane in 1993 and first stubble cane in 1994. The same four varieties as in the above test were harvested in plant cane on Sept. 1, Oct. 4, Nov. 2, and Dec. 1 in 1993. the plant cane

yields for the last three harvest dates are reported in Table 7. Results show that the plant cane yields increased progressively during the harvest season. The yield increases were significant during October and November in varieties CP 70-321 and LCP 85-384 and during November in varieties LCP 82-089 and LHo 83-153. Generally the percent sucrose increased during the harvest season in each variety. As an average of varieties, the cane and sugar yields increased significantly during October and November due to increases in average stalk weight and percent juice sucrose. Variety LCP 85-384 produced 20.9% more cane tonnage and 18.2% more sugar per acre than CP 70-321.

Stubble Protection

Experiments were conducted in 1993 to test the effects of stubble protection from freeze damage with a soil cover over cane stubbles during the winter months. One experiment was in first stubble cane to test the effects of dates of stubble soil cover after two harvest dates in plant cane with and without shaving in spring to remove the soil cover. Varieties CP 70-321 and LCP 82-089 were harvested as plant cane on Oct. 1 and Dec. 1 in 1992. The dates of the cover treatments were Cover 1 which was applied immediately after each harvest date and Cover 2 which was applied at the end of the harvest season in 1992. The shave treatment was applied in spring, 1993.

The first stubble yield data obtained in 1993 are reported in Table 8. Results show that stubble cane yields of each variety were increased by covering the cane stubbles immediately after harvesting plant cane in December but not in October (Cover 1). Removing the soil cover in spring with a shaver decreased stubble yields of both varieties for each harvest date (Cover 1 shave). Also, a soil cover applied at the end of the harvest season and removed in spring decreased yields for both varieties and harvest dates (Cover 2 shave). The results clearly show that a soil cover applied after harvesting plant cane in December and not removed in the spring can increase yield averaging 11.3% in first stubble cane. This practice can improve stubble cane yields and longevity.

Another experiment on stubble protection was conducted in second stubble cane to test soil cover with and without shaving to remove the cover in spring. Varieties CP 72-370 and CP 74-383 were planted in 1990 and harvested as plant cane in Dec., 1991 and first stubble in Nov., 1992. The soil cover treatment was applied each year immediately after harvesting the crop. The second stubble yield data obtained in 1993 are reported in Table 9. The results show that the stubble cane yields of each variety were increased with the soil cover where it was not removed by shaving in the spring. As an average, the soil cover increased cane yields 30.1% and sugar yields 45.8% in this second stubble test. These increases were due to increases in stalk population, average stalk weight and percent sucrose in the cane.

Stubble Cane Longevity Test

A stubble longevity experiment was initiated in 1991 and continued in first stubble in 1992 and second stubble cane in 1993 to test the effects of fall applied fertilizers, Furadan and stubble soil cover on cane yields. Varieties CP 72-370 and CP 74-383 were planted in the test. A 90-90-90 NPK fertilizer treatment was applied in the fall at planting time and a Furadan treatment at 10 lbs/A was applied at planting time and in spring of each crop year. A soil cover

treatment over the cane stubbles was applied after harvesting the plant cane and first stubble crops. The soil cover was removed with a stubble shaver and a 120-0-80 fertilizer was applied on all the plots in the spring of each crop year.

The factorial mean effects of each treatment for each variety in second stubble cane are reported in Table 10. The fall fertilizer applied at planting time significantly increased the sugar yield in CP 72-370 and the cane and sugar yields in CP 74-383. The Furadan treatment and the soil cover significantly increased the cane yields and sugar yields per acre in each variety. As an average of varieties, the sugar yields in this second stubble test were increased 7.8% with the fall applied fertilizer, 16.3% with Furadan and 11.1% with the soil cover. The results clearly show that these practices can be used to increase yield of older stubble cane and increase the longevity of stubble crops with acceptable yields into a third stubble crop.

Shaver, Stubble Digger, and Lilliston

An experiment was conducted in 1993 to evaluate the use of a stubble shaver, stubble digger, and a Lilliston cultivator on cane stands and yield of second stubble cane. Each tool was tested in varieties CP 65-357, CP 70-321, CP 72-370, and CP 74-383. The cane stubbles were shaved to ground level prior to applying the digger and cultivator in the spring of 1993. The data obtained are shown in Table 11. The second stubble cane yields were significantly decreased with the use of a stubble shaver in variety CP 74-383 and with the stubble digger and Lilliston cultivator in varieties CP 70-321 and CP 72-370. As an average of varieties, each tool significantly decreased the stubble cane yields. The yield decreases were mainly due to decreases in stalk population at harvest time. These tools should not be used in stubble cane unless it is absolutely necessary to incorporate herbicides in the soil in early spring.

Table 1. Effect of date of planting on the plant cane yield of four varieties of sugarcane on Commerce soil on the St. Gabriel Research Station, 1993.

Variety of cane	Date of planting	Plant cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
	1992	T/A	1000/A	lbs.	%	%	lbs/A
CP 70-321	Sept. 1	32.4	38.1	1.87	18.7	16.2	7696
	Oct. 1	31.2	35.2	2.20	18.3	15.9	7229
	Nov. 10	20.6	22.1	1.92	18.1	15.4	4591
LCP 82-089	Sept. 1	32.4	45.5	1.63	18.7	15.7	7405
	Oct. 1	32.3	35.2	2.03	18.2	15.2	7117
	Nov. 10	22.8	22.5	2.18	17.9	15.0	4964
LHO 83-153	Sept. 1	26.9	42.6	1.60	18.2	15.3	5976
	Oct. 1	28.8	38.2	1.72	18.3	15.2	6344
	Nov. 10	26.2	35.6	1.89	17.6	14.7	5535
LCP 85-384	Sept. 1	42.7	54.9	1.70	17.2	14.6	8923
	Oct. 1	40.5	44.0	1.82	17.4	14.7	8535
	Nov. 10	33.0	38.5	1.99	17.4	14.9	7094
LSD .05 Treatments		2.9	5.2	0.42	0.7	0.8	782
		Mean date effect					
	Sept. 1	33.6	45.3	1.70	18.2	15.5	7500
	Oct. 1	33.3	38.1	1.94	18.1	15.3	7306
	Nov. 10	25.6	29.7	1.99	17.8	15.0	5546
LSD .05 Means		1.4	2.6	0.21	0.3	0.4	391

Table 2. Effect of date of planting on the first stubble cane yield of four varieties of sugarcane on Commerce soil on the St. Gabriel Research Station, 1993.

Variety of cane	Date of planting	Stubble cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
	1991	T/A	1000/A	lbs.	%	%	lbs/A
CP 70-321	Sept. 1	27.2	34.9	1.93	18.4	15.9	6303
	Oct. 1	30.9	35.4	2.12	18.3	15.9	7176
	Nov. 6	29.3	36.7	2.14	18.3	15.8	6778
CP 72-370	Sept. 1	23.7	31.2	1.62	17.0	13.9	4695
	Oct. 1	28.8	38.0	1.85	17.3	14.4	5916
	Nov. 6	27.1	34.3	1.79	17.4	14.4	5579
CP 79-318	Sept. 1	26.5	25.4	2.70	17.2	14.5	5529
	Oct. 1	33.1	32.1	2.38	17.5	14.9	7116
	Nov. 6	28.8	27.0	2.93	17.4	14.7	6105
LCP 82-089	Sept. 1	26.7	38.0	1.65	18.3	15.3	5916
	Oct. 1	28.8	45.7	1.64	18.6	15.7	6572
	Nov. 6	24.2	36.4	2.00	18.1	15.2	5328
LSD .05 Treatments		2.4	3.7	0.34	0.8	0.8	629
		Mean date effect					
	Sept. 1	26.0	32.4	1.98	17.7	14.9	5611
	Oct. 1	30.4	37.8	2.00	17.9	15.2	6695
	Nov. 6	27.4	33.6	2.21	17.8	15.0	5947
LSD .05 Means		1.2	1.9	0.17	NS	NS	315

Table 3. Effect of rate of planting on plant cane yield of two varieties of sugarcane on Commerce soil on the St. Gabriel Research Station, 1993.

Variety of cane	Rate of planting	Plant cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
		T/A	1000/A	lbs.	%	%	lbs/A
LCP 82-089	2	30.7	31.9	2.23	17.9	15.2	6758
	3	30.5	35.0	2.15	17.9	15.1	6655
	4	31.7	32.6	1.96	17.7	14.9	6827
LHO 83-153	2	35.2	39.2	2.03	16.6	14.0	7033
	3	37.5	39.9	1.98	17.3	14.5	7826
	4	38.9	41.5	1.94	17.0	14.2	7890
LSD .05 Treatments		2.9	3.6	NS	0.7	0.8	829
		Mean date effect					
	2	33.0	35.6	2.13	17.3	14.6	6895
	3	34.0	37.5	2.07	17.5	14.8	7240
	4	35.3	37.1	1.95	17.3	14.6	7359
LSD .05 Means		2.0	NS	NS	NS	NS	NS

Table 4. Effect of depth of seed cover and shaving on the plant cane yield of two varieties of sugarcane on a Commerce soil on the St. Gabriel Research Station, 1993.

Seed cover depth	Shave treat.	Plant cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
		T/A	1000/A	lbs.	%	%	lbs/A
				LCP 82-089			
3-4	Check	27.4	29.4	2.15	17.4	14.7	5793
	Shave	31.5	29.8	2.27	17.6	14.8	6677
5-6	Check	32.7	29.2	2.09	17.4	14.6	6831
	Shave	34.2	33.3	2.19	17.9	15.2	7494
7-8	Check	32.2	33.3	2.22	17.4	14.7	6788
	Shave	32.7	34.1	2.32	17.6	15.0	7041
				LHO 83-153			
3-4	Check	27.2	31.9	1.87	17.1	14.4	5592
	Shave	30.5	34.1	2.03	16.8	14.1	6105
5-6	Check	31.7	36.5	1.97	16.8	14.1	6365
	Shave	34.0	36.6	2.09	17.3	14.6	7142
7-8	Check	30.5	32.6	1.93	16.6	13.8	5958
	Shave	35.2	36.9	2.16	16.9	14.2	7140
LSD .05 Treatments		2.8	3.5	0.25	0.6	0.7	677
				Mean Effect			
3-4		29.2	31.3	2.08	17.2	14.5	6042
5-6		33.1	33.8	2.09	17.4	14.6	6958
7-8		32.7	34.2	2.16	17.2	14.4	6732
	Check	30.3	32.2	2.04	17.1	14.4	6221
	Shave	33.0	34.1	2.18	17.4	14.6	6933
LSD .05 Depth Means		1.4	1.8	NS	NS	NS	339
LSD .05 Shave Means		1.1	1.4	0.10	NS	NS	276

Table 5. Effect of depth of seed cover and shaving on the first stubble cane yield of two varieties of sugarcane on a Commerce soil on the St. Gabriel Research Station, 1993.

Seed cover depth	Shave treat.	Stubble cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
		T/A	1000/A	lbs.	%	%	lbs/A
				CP 72-370			
3-4	Check	27.2	36.8	1.77	16.5	13.8	5335
	Shave	29.2	37.4	1.79	16.8	14.1	5890
5-6	Check	28.3	35.9	1.68	16.4	13.8	5532
	Shave	27.9	34.0	1.89	16.5	13.8	5483
7-8	Check	23.2	30.2	1.76	15.9	13.2	4311
	Shave	24.8	31.7	1.83	15.2	12.6	4358
				LCP 82-089			
3-4	Check	31.0	38.8	1.80	17.0	14.2	6316
	Shave	31.7	38.0	1.84	17.1	14.2	6418
5-6	Check	28.3	40.0	1.81	17.6	14.9	6052
	Shave	30.6	39.5	1.81	17.1	14.3	6270
7-8	Check	30.8	44.1	1.76	18.2	15.7	6999
	Shave	30.0	43.1	1.64	17.3	14.5	6272
LSD .05 Treatments		2.5	2.2	0.23	0.9	1.2	656
				Mean Effect			
3-4		29.8	37.7	1.80	16.9	14.1	5990
5-6		28.8	37.3	1.80	16.9	14.2	5834
7-8		27.2	37.3	1.75	16.6	14.0	5485
	Check	28.1	37.6	1.76	16.9	14.3	5758
	Shave	29.0	37.3	1.80	16.7	13.9	5782
LSD .05 Depth Means		1.2	NS	NS	NS	NS	328
LSD .05 Shave Means		NS	NS	NS	NS	NS	NS

Table 6. Effect of date of harvesting plant cane on yield of the subsequent stubble cane of four varieties on Commerce soil on the St. Gabriel Research Station, 1993.

Variety of cane	Date of plant cane harvest	Stubble cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
	1992	T/A	1000/A	lbs.	%	%	lbs/A
CP 70-321	Sept. 1	21.4	31.2	1.59	17.6	15.0	4612
	Oct. 1	22.9	42.2	1.61	18.3	15.7	5214
	Nov. 10	27.8	35.9	1.96	18.4	15.8	6380
	Dec. 1	27.9	36.8	1.74	18.9	16.3	6653
LCP 82-089	Sept. 1	20.6	33.0	1.44	18.4	15.5	4647
	Oct. 1	22.7	39.1	1.62	18.5	15.4	5068
	Nov. 10	25.4	35.0	1.63	18.7	15.8	5829
	Dec. 1	27.0	44.8	1.52	18.6	15.6	6139
LHO 83-153	Sept. 1	18.1	29.3	1.20	18.0	15.0	3899
	Oct. 1	20.0	43.7	1.10	17.9	14.7	4229
	Nov. 10	21.4	34.6	1.25	18.5	15.4	4771
	Dec. 1	22.6	49.3	1.22	17.9	14.8	4810
LCP 85-384	Sept. 1	37.2	51.6	1.55	18.7	16.0	5702
	Oct. 1	38.1	57.8	1.63	18.6	15.9	8801
	Nov. 10	35.7	52.5	1.45	18.0	15.2	7855
	Dec. 1	38.7	57.1	1.50	18.2	15.5	8601
LSD .05 Treatments		2.9	5.9	0.32	0.6	0.7	730
				Mean date effect			
	Sept. 1	24.3	36.3	1.45	18.2	15.4	5465
	Oct. 1	25.9	45.7	1.49	18.3	15.4	5828
	Nov. 10	27.6	39.5	1.57	18.4	15.5	6209
	Dec. 1	28.9	47.0	1.49	18.4	15.5	6551
LSD .05 Means		1.4	3.0	NS	NS	NS	365

Table 7. Effect of date of harvest on the yield of four varieties of plant cane on Commerce soil on the St. Gabriel Research Station, 1993.

Variety of cane	Date of plant cane harvest	Plant cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
	1993	T/A	1000/A	lbs.	%	%	lbs/A
CP 70-321	Oct. 4	29.3	39.0	1.71	17.5	15.3	6443
	Nov. 2	34.2	37.3	2.03	17.8	15.4	7616
	Dec. 1	41.6	39.6	2.13	17.4	15.3	9252
LCP 82-089	Oct. 4	29.7	38.8	1.63	17.1	14.3	6085
	Nov. 2	32.6	39.9	1.81	17.6	14.9	7004
	Dec. 1	40.3	38.7	2.07	17.8	15.5	9025
LHO 83-153	Oct. 4	26.0	39.9	1.41	16.5	13.8	5106
	Nov. 2	29.6	42.3	1.54	17.5	14.5	6171
	Dec. 1	36.0	46.1	1.58	17.8	15.3	7949
LCP 85-384	Oct. 4	38.0	48.0	1.81	16.4	14.1	7655
	Nov. 2	43.3	50.3	1.99	17.2	15.0	9367
	Dec. 1	50.3	50.8	2.03	17.1	15.1	10938
LSD .05 Treatments		3.7	4.4	0.23	1.0	0.5	955
		Mean date effect					
	Oct. 4	30.7	41.4	1.64	16.9	14.4	6322
	Nov. 2	34.9	42.4	1.85	17.5	15.0	7540
	Dec. 1	42.0	43.8	1.95	17.5	15.3	9291
LSD .05 Means		1.9	2.2	0.12	0.5	0.6	477

The plant cane of each variety was harvested on four dates and the yields were measured on the last three dates in 1993.

Table 8. Effect of stubble protection after two harvest dates of two cane varieties on the yield of the subsequent stubble crop on the St. Gabriel Research Station, 1993.

Date of plant cane harvest	Stubble protection treatment	Stubble yield 1993	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
1992	1992	T/A	1000/A	lbs.	%	%	lbs/A
			CP 70-321				
Oct. 1	Check	30.0	37.6	2.31	17.8	15.3	6651
	Cover 1	28.5	32.0	2.01	17.6	15.1	6235
	Cover 1 shave	23.2	30.3	2.19	18.0	15.2	5112
	Cover 2 shave	27.4	30.2	2.11	17.8	14.9	5875
Dec. 1	Check	31.7	34.3	2.42	18.0	15.7	7231
	Cover 1	35.6	30.4	2.23	17.2	15.0	7716
	Cover 1 shave	28.8	31.9	2.21	17.2	15.1	6261
	Cover 2 shave	26.0	29.5	2.10	17.8	15.7	5945
			CP 82-089				
Oct. 1	Check	28.5	37.6	2.06	17.3	15.2	6261
	Cover 1	28.0	28.7	1.99	16.9	14.6	5881
	Cover 1 shave	22.1	29.9	1.82	16.6	14.1	4469
	Cover 2 shave	22.7	30.2	1.59	16.5	14.1	4546
Dec. 1	Check	26.3	34.6	1.74	18.1	15.7	6006
	Cover 1	29.0	33.8	1.99	17.9	15.5	6517
	Cover 1 shave	25.0	34.0	1.64	18.0	15.5	5624
	Cover 2 shave	24.4	29.8	1.76	18.2	15.6	5519
LSD .05 Treatments		2.7	3.6	0.27	0.7	0.8	586
			Mean cover effect				
	Check	29.1	36.0	2.13	17.8	15.5	6537
	Cover 1	30.3	31.2	2.05	17.4	15.1	6587
	Cover 1 shave	24.8	31.5	1.97	17.5	15.0	5366
	Cover 2 shave	25.1	29.9	1.89	17.6	15.1	5471
LSD .05 Means		1.3	1.8	0.14	0.4	0.4	293

Cane stubbles were covered after harvesting plant cane. Cover 1 was applied immediately after each harvest date and Cover 2 was applied at the end of the harvest season in December, 1992.

Table 9. Effect of stubble protection on the second stubble yield of two cane varieties the St. Gabriel Research Station, 1993.

Stubble protection treatment	Stubble yield 1993	Stalk		Normal juice		Sugar yield
		No.	Wt.	Brix	Sucrose	
1992	T/A	1000/A	lbs.	%	%	lbs/A
			CP 72-370			
Check-shave	18.2	27.3	1.58	14.1	11.2	2759
Cover	27.2	35.6	1.81	14.8	11.9	4444
Cover-shave	20.5	29.7	1.42	14.4	11.5	3190
			CP 74-383			
Check-shave	27.0	41.9	1.45	14.7	11.6	4314
Cover	31.5	43.1	1.73	16.0	13.3	5871
Cover-shave	25.7	44.2	1.43	15.1	11.9	4220
LSD .05 Treatment	3.3	3.0	0.20	0.9	1.2	661
			Mean cover effect			
Check-shave	22.6	34.6	1.52	14.4	11.4	3536
Cover	29.4	39.4	1.77	15.4	12.6	5158
Cover-shave	23.1	36.9	1.43	14.7	11.7	3705
LSD .05 Means	2.3	2.1	0.14	0.7	0.9	468

Cane stubbles were covered with soil after harvesting plant cane in Dec. 1991 and first stubble cane in Nov. 1992. A shaver was used to remove the soil cover in the following spring of each crop year.

Table 10. Mean effects of fall applied fertilizer, Furadan and soil cover on second stubble yield of CP 72-370 and CP 74-383 on a Commerce soil on the St. Gabriel Research Station, 1993.

Fall Fertilizer $N-P_2O_5-K_2O$	Furadan	Soil cover	Stubble cane yield	Stalk		Normal juice		Sugar yield
				No.	Wt.	Brix	Sucrose	
lbs/A			T/A	1000/A	lbs.	%	%	lbs/A
				CP 72-370				
0-0-0			24.7	30.8	1.66	16.0	13.0	4474
90-90-90			25.7	31.7	1.81	16.0	13.2	4769
	Check		24.1	29.7	1.77	15.9	12.9	4375
	Furadan		26.3	32.7	1.70	16.1	13.2	4869
		Check	23.9	30.9	1.72	16.0	13.0	4371
		Cover	26.5	31.6	1.75	16.0	13.1	4873
LSD .05			1.4	2.6	NS	NS	NS	292
				CP 74-383				
0-0-0			29.1	41.1	1.79	16.7	13.8	5698
90-90-90			31.6	44.2	1.71	16.3	13.7	6199
	Check		28.9	41.1	1.67	16.4	13.3	5399
	Furadan		31.9	44.2	1.83	17.1	14.3	6498
		Check	28.9	40.7	1.80	16.7	13.7	5637
		Cover	31.9	44.6	1.70	16.7	13.8	6259
LSD .05			1.4	2.3	0.10	0.3	0.4	275

The fall fertilizer treatment was applied in the planting furrows and a 120-0-80 fertilizer was applied to all plots in the spring. The Furadan treatment at 10 lbs/A was applied in the fall and spring. The soil cover on cane stubbles was applied after harvesting plant cane in 1991 and first stubble in 1992.

Table 11. Effect of a shaver, stubble digger and Lilliston cultivator on second stubble yield of four varieties on Commerce soil on the St. Gabriel Research Station, 1993.

Cane Variety	Treatment	Stubble cane yield	Stalk		Normal juice		Sugar yield
			No.	Wt.	Brix	Sucrose	
		T/A	1000/A	lbs.	%	%	lbs/A
CP 65-357	Check	22.6	32.9	1.70	15.3	12.4	3896
	Shaver	23.5	33.0	1.74	14.7	11.4	3670
	Digger	21.5	32.4	1.57	14.9	11.6	3424
	Lilliston	21.7	32.4	1.56	14.8	11.5	3426
CP 70-321	Check	26.6	35.5	1.76	16.1	13.1	4911
	Shaver	24.6	32.0	1.79	15.2	12.2	4150
	Digger	23.4	31.1	1.69	15.1	12.1	3890
	Lilliston	23.3	29.4	1.88	14.6	11.5	3640
CP 72-370	Check	23.5	32.9	1.41	15.0	12.2	3964
	Shaver	21.9	31.8	1.56	15.0	12.0	3624
	Digger	18.8	28.9	1.57	14.9	11.8	3059
	Lilliston	19.3	30.9	1.47	15.4	11.8	3150
CP 74-383	Check	29.1	42.7	1.43	16.0	13.1	5386
	Shaver	25.7	37.1	1.61	15.3	12.3	4371
	Digger	26.6	39.4	1.53	15.4	12.2	4517
	Lilliston	28.0	40.4	1.63	15.7	12.7	4988
LSD .05 Treatments		2.3	2.5	0.17	0.8	1.0	642
				Mean effect			
	Check	25.5	36.0	1.58	15.6	12.7	4539
	Shaver	23.9	33.5	1.67	15.1	12.0	3954
	Digger	22.6	33.0	1.59	15.1	11.9	3722
	Lilliston	23.1	33.3	1.63	15.1	11.9	3801
LSD .05 Means		1.1	1.2	0.09	0.4	0.5	321

Cane stubbles were shaved to ground level prior to applying the digger and Lilliston.

INFLUENCE OF FALLOW-YEAR LEGUMES ON SUGARCANE GROWN ON A SOIL RELATIVELY HIGH IN ORGANIC MATTER

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Summary:

This study was conducted to evaluate the effects of preceding hairy vetch, green manure soybean, and cash soybean crops and/or applied N fertilizer on sugarcane yield and N uptake (product of dry matter percentage and plant nitrogen content). The experiment was conducted on soil relatively high in organic matter for the Bayou Teche region. The cane and sugar yields of LCP 82-89 for all crops of the cycle were not influenced by the presence of the legume crops during the fallow year. Average cane cycle yields following the fallow check, hairy vetch, green manure soybeans, and cash soybeans were 6,588, 6,248, 6,389, and 6,368 pounds of sugar per acre, respectively. In the plantcane crop immediately following the fallow period, N uptake increased ($P=.07$) with applied fertilizer N, but sugar/acre yields were unaffected by the addition of N fertilizer. Nitrogen uptake was not influenced by fallow-year treatments. Assignment of N credits to previous legume crops was not possible because yield of unfertilized cane following the fallow check was equivalent to cane receiving N fertilizer. The ability of unfertilized plantcane following the fallow check to yield equivalent to cane benefitting from both additional organic and inorganic N suggests N available from the indigenous soil organic pool in this relatively high organic matter soil was sufficient for adequate yields.

Introduction:

Sugarcane growers often include fallow-year legumes in their rotation to enhance cash flow, enrich and protect soil, and substitute for conventional seedbed preparation costs. The extent to which such cultural systems reduce the need for chemical fertilizer has not been quantified. Possible adverse effects of legumes to the subsequent sugarcane cycle have also not been sufficiently evaluated. The objectives of this investigation are to quantify the benefits and/or consequences and measure the influence on soil properties of legume cover and cash crops grown in rotation with sugarcane.

Experimental Procedures:

The experiment was conducted on a Baldwin silty clay loam with an initial organic matter content of 2.8%. Hairy vetch was seeded at 30 pounds per acre after inoculation with appropriate N-fixing bacteria. The seed was planted on sugarcane rows using two drills apart. Vetch biomass samples (2' x 6') were harvested from the plots for nitrogen content determination by Kjeldahl at the Forage Quality Evaluation Laboratory at the Southeast Research Station in Franklinton, LA. In April, early maturity soybeans, intended for both cover and cash purposes, were seeded. Hairy vetch was flailed and incorporated in the rows at full bloom. Soybean plantings were accomplished using an IH air-seeder with planting units spaced 18 inches apart, using a planting rate of 6-8 seed per foot of row. Preemergence herbicides for all soybean plots were 1 1/2 pints of Dual and 2/3 pounds of Lexone per acre. The fallow control

plots also received the preemergence application of Dual + Lexone. Plot size was three rows, each 52 feet in length.

Benlate fungicide was applied on July 2, 1990, at the rate of 3/4 pound of formulated material per acre to protect all plots scheduled for bean harvest. Cover crop plots were not sprayed with Benlate. At early leaf drop, the soybean treatments were sampled for nitrogen content, using a 5' section of row. LCP 82-89 sugarcane was planted on all plots on October 7, 1990. Nitrogen content of sugarcane was determined for whole plant samples at the plantcane and first stubble harvests. Six stalks, with tops and leaves, of each plot were randomly selected and analyzed for nitrogen content using micro Kjeldahl.

Cane grown on the plots receiving the fallow-year treatments (fallow, cover, and cash crops) were fertilized with both a full and zero complement of recommended nitrogen fertilizer in the plantcane crop. Stubble crops received recommended rates of a complete fertilizer on all plots.

Treatments were evaluated using a randomized block design, with three replications.

Results:

Figure no. 1 compares cane cycle sugar per acre yields following the fallow-year treatments. Sugar yield was not significantly affected by legume occupation of the fallow period. Average cycle yields were 6,588, 6,248, 6,389, and 6,368 pounds of sugar per acre, respectively, for the fallow check, hairy vetch, green manure soybean, and cash soybean treatments. The lack of response by sugarcane to organic N in legume residue was surprising. More surprising was the failure of plantcane to respond to fertilizer N, especially when coupled with legume residues. The amount of N measured on a whole-plant basis in plantcane (figure no. 2) increased with the application of N fertilizer, but the effect on cane yield receiving both fertilizer and organic N was not additive. N uptake of unfertilized cane following the conventional fallow period was comparable to cane benefitting from both fertilizer N and legume residue. Results strongly indicate that indigenous organic N of the soil chosen for this study mineralizes sufficient N to support a plantcane crop in a conventional fallow sequence.

The insensitivity of sugarcane to the addition of organic N in the form of incorporated legumes may be attributable partially to the lag in time between legume incorporation or harvest and the resumption of cane growth in the spring, a period of up to nine months. Louisiana's relatively mild winters tend to support year-round mineralization of N, but excessive rainfall promotes leaching and denitrification in certain soil environments. An accompanying article reports increases in soil nitrate concentrations in the surface 1-ft with the addition of soybean residues, but at levels considerably lower than that required for maximum yields.

Additional research is needed to fully understand the benefits and consequences of the utilization of legumes in rotation with sugarcane.

Figure no. 1 - Cane cycle response to fallow-year treatments on high organic matter soil

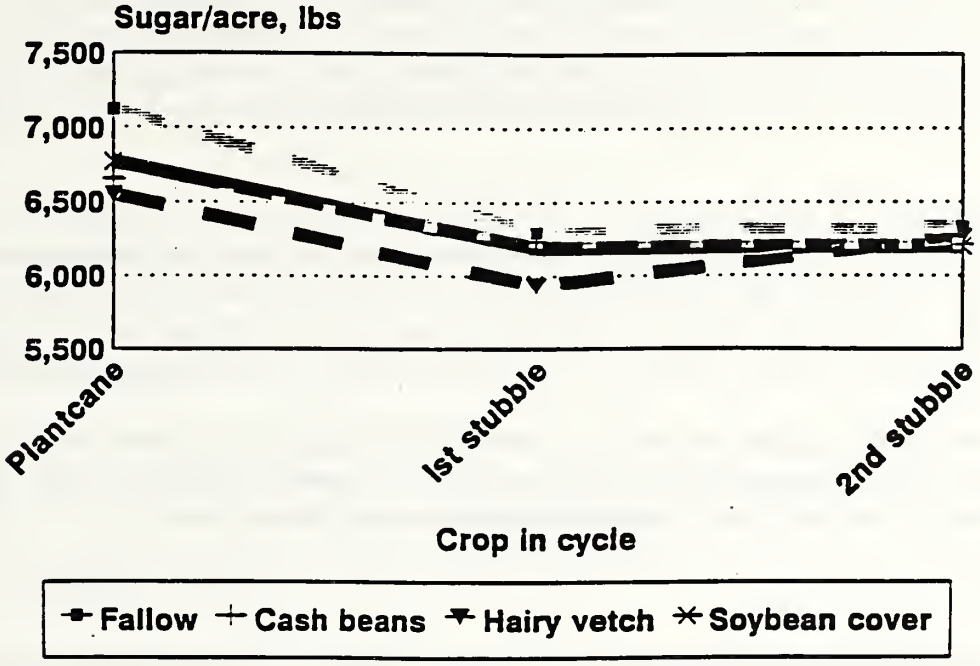
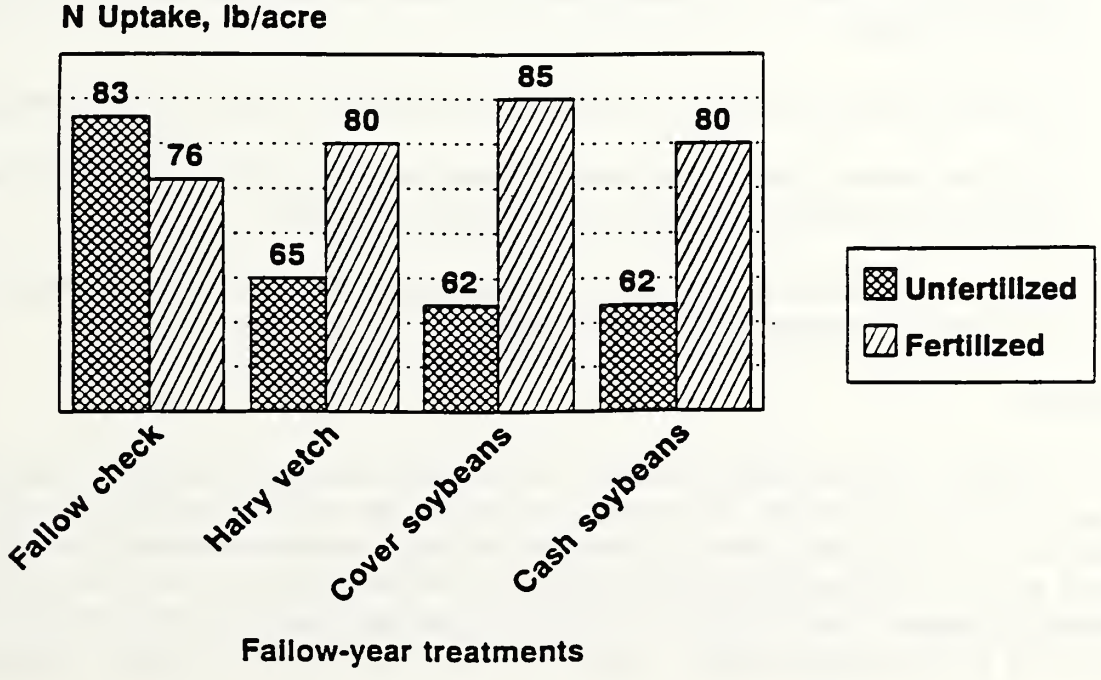


Figure no. 2 - Nitrogen Uptake of Plantcane



EFFECT OF COMPOSTED MUNICIPAL WASTE AND SUGARMILL WASTE ON SUGARCANE YIELD PARAMETERS

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Summary:

A nitrogen x waste product study was conducted on plant cane in 1993 on a Jeanerette silt loam soil. Nitrogen rates consisted of 15 and 150 lbs/A. Waste product treatments were composed of: 1) boiler ash (20 T/A); filter press mud (17 T/A); liquid fish (24 gallons/A); bagasse (15 T/A) and liquid sewage (3.6 T/A); and composted municipal waste (40 T/A).

Boiler ash and bagasse + sewage decreased ($P \leq 0.10$) CRS. There was also a trend ($P \leq 0.25$) for liquid fish to increase CRS; compost to increase stalk weights; boiler ash to decrease sugar/A; and nitrogen to increase cane tonnage and sugar yields.

Introduction:

Municipalities and sugarmills face a growing problem of how to dispose of their solid waste. A possible solution to this problem is to use these waste materials in sugarcane production.

Objectives of our study were to:

1) Determine the effect of composted municipal waste and sugarmill waste on sugarcane yield parameters.

2) Determine the effect of compost on chemical composition of soil and sugarcane plants.

3) Determine whether compost and sugarmill waste can be economically used to replace or supplement commercial fertilizer in the growing of sugarcane.

4) Determine whether using compost and sugarmill waste can prolong the sugarcane cycle by producing respectable third stubble yields.

Procedures:

In August, 1992 a sugarcane fertilizer x waste product study was initiated on a Jeanerette silt loam soil in St. Mary Parish. The experimental design was a randomized split-plot with four replications. Fertilizer rates served as main plots and waste products comprised the split plots (tables 1 and 2). All experimental plots received 15, 40, and 120 lbs N, K_2O, and P_2O_5/A as a blanket application in April of 1993. The high fertilizer rate main plot received an additional 135 lbs N/A as UAN in April 1993. The six sub-plots consisted of: 1) a check; 2) boiler ash

applied to opened rows on August 18, 1992 at 20 T/A; 3) filter press mud applied on August 19, 1992 at 17 T/A; 4) liquid fish applied at 24 gallons/A in April, 1993 in the off-bar; 5) bagasse applied on August 19, 1992 at 15 T/A in opened rows; and 6) 40 T/A of composted municipal waste (supplied by the Bedminster Bioconversion Corporation) applied on September 5, 1992 on top of planted cane in opened rows. After the boiler ash, filter press mud, and bagasse were applied to opened rows in August of 1992 and the rows were closed until the cane was planted in early September with Kleentek LCP 82-89 at two stalks and a lap of two joints. In mid-May, 1993 lime treated sewage sludge (3.6 T/A, 60 lbs N/A) was applied to treatment #'s 5 and 11.

All experimental plots consisted of three 5'10" by 48' rows with 8' alleys separating the plots. The experimental plots were grown till maturity in December, 1993 when they were harvested.

Results and Discussion:

Applying nitrogen and waste materials did not significantly ($P \leq 0.10$) affect any of the measured yield parameters (tables 1 and 2), except CRS. There was, however, a trend ($P \leq 0.25$) for nitrogen (N) to affect cane tonnage and sugar/A, and for waste materials (W) to affect stalk weight and sugar/A. There was no significant N x W interaction for any of the variables measured (Table 1).

Table 3 shows that there was a trend ($P \leq 0.25$) for nitrogen to increase cane tonnage and sugar/A.

Table 4 shows that boiler ash and bagasse + sewage significantly ($P \leq 0.10$) decreased CRS. There was also a trend ($P \leq 0.25$) for liquid fish to increase CRS; compost to increase stalk weights; and boiler ash to decrease sugar/A.

Table 1. F-values for effect of nitrogen fertilizer, compost, and sugarmill wastes on plant cane yield parameters on a Jeanerette silt loam soil at Franklin in 1993.

Source	df	Stalk wt.	Population	CRS	Cane Yield	Sugar yield
Nitrogen (N)	1	0.42	0.93	0.32	4.04°	3.51°
Compost and waste materials (W)	5	1.82°	1.35	3.33*	1.16	1.53°
N x W	5	0.58	1.01	0.43	0.26	0.20
%CV for N		14.05	36.85	7.56	26.11	26.39
%CV for W		11.11	13.88	3.53	9.33	9.47
RMSE FOR N		0.2520	6437	16.83	8.434	1892
RMSE for W		0.1992	2423	7.863	3.014	678.7

° and * denote statistical significance at the P≤0.25 and 0.05 levels, respectively. Removing F-values were not significant at P≤0.25 .

Table 2. Effect of nitrogen fertilizer, compost, and sugarmill wastes on plant cane yield parameters on a Jeanerette silt loam soil at Franklin in 1993.

T#	N	Waste	Millable Stalk Wt.	Millable Stalk No.	CRS	Cane yield	Sugar yield
	lbs/A		lbs	1000/A	lbs/T	T/A	lbs/A
1	15*	None	1.65	16.3	227	30.2	6830
2	15	boiler ash	1.75	16.6	218	28.9	6200
3	15	filter press mud	1.74	16.8	225	29.7	6680
4	15	liquid fish	1.73	16.7	232	28.2	6550
5	15	bagasse + sewage	1.85	16.8	217	30.0	6500
6	15	compost	1.91	16.2	224	32.1	7190
7	150*	None	1.82	19.4	220	34.9	7660
8	150	boiler ash	1.88	19.2	216	33.6	7280
9	150	filter press mud	1.75	19.5	227	33.3	7570
10	150	liquid fish	1.67	18.9	227	35.1	7960
11	150	bagasse + sewage	1.76	18.4	216	34.8	7530
12	150	compost	2.02	14.7	220	36.73	8090
LSD 0.10 for N			NS	NS	NS	NS	NA
LSD 0.25 for N			NS	NS	NS	NA	NA
LSD 0.10 for W			NS	NS	NA	NS	NA
LSD 0.25 for W			NA	NS	NA	NS	NA

† All treatment plots received 15 lbs N, 40 lbs K_2O, and 120 lbs P_2O_5/A as a blanket application. The 150 lbs N/A treatments received an additional 135 lbs N/A as UAN.

NS Denotes that the treatment means were not different at the indicated P levels.

NA Denotes that LSD values are not given because the N x W interaction was not significant at $P \leq 0.25$.

Table 3. Effect of nitrogen fertilizer on plant cane yield parameters on a Jeanerette silt loam soil at Franklin in 1993.

	Millable stalk				
Nitrogen	Wt.	No.	CRS	Cane yield	Sugar yield
lbs N/A	lbs	1000/A	lbs/T	T/A	lbs/A
15	1.77	16.6	224	29.9	6660
150	1.82	18.4	221	34.7	7680
LSD 0.10	NS	NS	NS	NS	NS
LSD 0.25	NS	NS	NS	3.5	780

NS Denotes that nitrogen did not affect the indicated yield parameter at the designated P level.

Table 4. Effect of compost and sugarmill waste on plant cane yield parameters on a Jeanerette silt loom soil at Franklin in 1993.

Waste	Millable stalk Wt.	Millable stalk No.	CRS	Cane Yield	Sugar Yield
	lbs	1000/A	lbs/T	T/A	lbs/A
None	1.74	17.8	224	32.5	7250
boiler ash	1.82	17.9	217	31.3	6740
filter press mud	1.75	18.2	226	31.5	7120
liquid fish	1.70	17.8	230	31.7	7260
bagasse + sewage	1.80	17.6	216	32.4	7010
compost	1.97	15.5	222	34.4	7640
LSD 0.10	NS	NS	7	NS	NS
LSD 0.25	0.12	NS	5	NS	400

NS Denotes that the treatment means were not significantly different at the indicated P levels.

EFFECT OF COMPOSTED MUNICIPAL WASTE ON SUGARCANE PRODUCTION AND FERTILIZER REQUIREMENTS

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Summary:

Semi-banding 10 T/A of compost under cane at planting in 1990 increased ($P \leq 0.10$) second stubble cane tonnage (3.7 T/A) in 1993 on a Baldwin silty clay soil where the recommended rate of fertilizer was used. Compost application also resulted in higher yield responses from fertilizer application (9.1 T/A where compost was not added vs. 13.4 T/A where 10 T/A of compost was applied). While compost did not significantly ($P \leq 0.10$)increase sugar yields in second stubble cane, there was a trend ($P \leq 0.25$) toward higher yields (600 lbs sugar/A) where 10 T/A of compost was added in 1990. As with cane tonnage, compost application resulted in higher sugar/A yield responses from fertilizer application (2360 lbs/A where 10 T/A of compost was added vs. 1820 lbs/A where compost was not added). There was also a trend ($P \leq 0.25$) toward higher yields where 1 T/A of compost was applied in the off-bar with fertilizer in the spring.

Applying and incorporating compost rates up to 100 T/A in 1991 before planting resulted in increased ($P \leq 0.25$) sugar yields of 1000 lbs/A with first stubble cane where fertilizer was not applied on a Baldwin silty clay soil in 1993. Sugar yield responses from fertilizer application became progressively smaller as the 1991 compost application rates increased (1680 lbs/A where compost was not applied vs. 340 lbs/A where 100 T/A of compost was applied).

Compost rates up to 75 T/A applied and incorporated before planting in 1991 on a Memphis silt loam soil did not affect ($P \leq 0.25$) either cane tonnage or sugar/A with first stubble cane in 1993.

Introduction:

Municipalities face a growing problem of how to safely dispose of their sewage sludge and solid waste. At present, due to lack of land and concern for the environment, many landfills are closed or are being closed. The landfill in Iberia Parish was terminated and solid waste is now trucked out of the parish at considerable cost. Surrounding parishes face similar problems. A possible solution to this problem is to make compost from sewage sludge and solid waste. The compost could then be used for agricultural purposes.

One approach for making compost is that used by the Bedminster Bioconversion Corporation. The "Bedminster Process" combines sewage sludge with solid waste in a "three day turning drum process". This results in a compost that is free of harmful organisms. Research is needed to determine whether this material can be safely and profitably used in growing sugarcane.

Objectives of our study were to:

1) Determine the effect of compost on sugarcane yields.

2) Determine whether compost can be economically used to replace or supplement commercial fertilizer in the growing of sugarcane.

3) Determine the effect of compost on the chemical composition of soil and sugarcane plants.

Procedures:

In October, 1990 a fertilizer by compost study was initiated at the Iberia Research Station on a Baldwin silty clay soil. The experiment consisted of the twelve treatments given in Table 2, replicated three times in a randomized complete block design. Experimental plots consisted of three 5'10" by 48' rows, separated by 8' alleys at the ends of the plots.

All plots received either 0, 5, or 10 tons/A of compost (Table 2) applied to opened rows in early-October, 1990. The rows were then closed until planting. In late October the rows were opened and Kleentek seedcane of the variety CP65-357 was planted at three stalks and a lap of two joints. The rows were then closed to allow the sugarcane to germinate.

In March, 1993 the sugarcane rows were off-barred to allow the soil to warm up. In mid-April, the fertilizer and compost rates indicated in Table 2 were applied to the left off-bar of each row; the rows were "hipped-up" to cover the compost and fertilizer in the off-bar; and the cane was grown to maturity using standard cultural practices.

Two additional compost by fertilizer experiments were initiated in the fall of 1991. The first was grown on a Baldwin silty clay soil at the Iberia Research Station at Jeanerette (tables 3-6), where compost was applied in early-October and spread across rows from furrow-to-furrow at 0, 20, 40, 60, 80, and 100 T/A (dry weight basis) and disked into the rows twice. The rows were then opened and planted to Kleentek seedcane of the variety CP70-321 at three stalks and a lap of two joints in mid-October.

The second test was grown on a Memphis silt loam soil at Youngsville in cooperation with Mr. Wilson Viator (tables 7-10). In this study, compost was applied at 0, 15, 30, 45, 60, and 75 T/A on top of the rows in early September 1991 and disked into the rows twice. The rows were then opened in mid-September and planted with first progeny Kleentek seedcane of the variety CP70-321 at three stalks and a lap of two joints.

Both the Jeanerette and Youngsville tests used a randomized complete block design with three replications. Plots consisted of five 5'10" by 48' rows with 8' alleys at the ends of the plots and a border row separating the plots. Fertilizer was applied to the right off-bar of all rows receiving fertilizer in April of 1993 at 160 lbs N, 90 lbs P_2O_5, 120 lbs K_2O, and 24 lbs S/A. The rows were "hipped-up" to cover the fertilizer, and cane was grown to maturity using standard cultural practices.

In September of 1993, sugarcane stalks in all plots, of all three studies, were counted to determine the effects of the treatments on plant population. The plots were then harvested in November and December and weighed with a weigh rig. A 10 stalk sample was taken from each plot to determine average stalk weight and juice quality.

Results and Discussion:

Compost and fertilizer treatments affected ($P \leq 0.10$) second-stubble plant population, cane yield, and sugar yield at Jeanerette in 1993 (Table 1). Fertilizer rates increased cane tonnage within all three of the compost rates applied in 1990 (Table 2). Fertilizer increased cane yield 9.1 T/A where no compost was applied in 1990; 11.4 T/A where compost was added at 5 T/A; and 13.4 T/A where 10 T/A of compost was applied. Consequently, applying 10 T/A of compost in 1990 allowed the fertilizer to obtain an additional 4.3 T/A of cane as second stubble compared to where compost was not applied. The increase in cane tonnage with fertilizer application was, apparently, caused by the effect of fertilizer on plant population (Table 2).

Adding 10 T/A of compost before planting in 1990 increased ($P \leq 0.10$) yields 3.7 T/A where the full rate of fertilizer was used (T#12 vs. T#4) but not where fertilizer was not added (T#9 vs. T#1). This demonstrates again the positive interaction between fertilizer and compost on yield.

As with cane tonnage, fertilizer application increased ($P \leq 0.10$) sugar/A (Table 2) at all three compost rates (0, 5, and 10 T/A). However, the increase in sugar yield with fertilizer addition was greater (2360 vs. 1820 lbs/A) where compost was added at 10 T/A versus where it was not added. This shows the synergistic effect of compost on sugar yield response to fertilizer application.

Adding 10 T/A of compost in 1990 did not increase sugar/A in 1993 at the $P \leq 0.10$ level. However, there was a trend ($P \leq 0.25$) toward higher yields with compost application where the full rate of fertilizer was used (T#12 vs. T#4).

Adding 1 T/A of compost in the offbar with fertilizer in 1993 did not significantly ($P \leq 0.10$) increase plant population, cane tonnage, or sugar/A. However, it did result in a trend ($P \leq 0.25$) toward higher tonnage and increased sugar yields (T #11 vs. T #10).

The effects of compost and fertilizer on first stubble yield parameters at Jeanerette in 1993 are given in tables 3-6. Fertilizer affected ($P \leq 0.10$) CRS, cane yield, and sugar yield, while the main effect of compost was not significant for any of the parameters measured. There were, however, fertilizer x compost interactions for CRS ($P \leq 0.10$) and for stalk weight and sugar yield ($P \leq 0.25$).

Table 4 shows that fertilizer increased ($P \leq 0.10$) CRS where 0, 20, 40, and 80 T/A of compost was added in 1991 before planting. There was also a trend ($P \leq 0.25$) toward higher sugar/A yields with fertilizer addition at the 0, 20, 40, 60, and 80 T/A compost rates.

Higher sugar yield responses with fertilizer application in the absence of compost (1680 lbs/A) versus where 100 T/A of compost was added (340 lbs/A) indicates that high compost rates reduced the need for commercial fertilizer.

While compost did not significantly ($P \leq 0.10$) increase sugar/A yields (table 4) there was a trend ($P \leq 0.25$) toward higher yields with compost addition where fertilizer was not used (T #11 vs. T #1). There was also a trend towards heavier stalk weights with compost addition (Table 4) in the absence of fertilizer (T #'s 5 and 9 vs. T #1).

Table 7 shows that the main effects of compost and fertilizer on yield parameters were not significant ($P \leq 0.25$) for first stubble cane at Youngsville in 1993. There was, however, a significant ($P \leq 0.05$) fertilizer x compost interaction for plant population (tables 7 and 8).

Table 1. F-values for effect of fertilizer and compost addition on second stubble sugarcane yield parameters for a Baldwin silty clay soil at the Iberia Research Station in 1993.

Source	df	Stalk wt.	Population	CRS	Cane yield	Sugar yield
Treatments	11	1.18	3.08*	0.24	11.77****	8.32****
% CV		11.72	8.41	11.26	8.56	10.89
RMSE		0.2117	2258	19.83	2.239	499.6

* and **** denote statistical significance at the P≤0.05, and 0.0001 levels, respectively. Remaining F-value was not significant at P≤0.25.

Table 2. Effect of fertilizer and compost on second stubble yield parameters at Jeanerette in 1993.

T#	1990† Compost	Fert.†	1993§ Compost	Millable stalk Wt.	Millable stalk No.	CRS	Cane yield	Sugar yield
	T/A		T/A	lbs	1000/A	lbs/T	T/A	lbs/A
1	0	0	0	1.56	26.5	171	20.0	3,440
2	0	0.5x	0	1.85	26.9	166	27.4	4,560
3	0	0.5x	1.0	2.05	26.8	181	27.6	4,990
4	0	1.0x	0	1.84	29.1	181	29.1	5,260
5	5	0	0	1.65	22.4	170	18.9	3,200
6	5	0.5x	0	1.81	28.5	176	26.6	4,680
7	5	0.5x	1.0	1.86	28.8	172	26.9	4,620
8	5	1.0x	0	1.76	28.1	182	30.3	5,470
9	10	0	0	1.70	22.2	185	19.4	3,500
10	10	0.5x	0	1.84	26.5	175	26.1	4,510
11	10	0.5x	1.0	1.76	27.8	175	28.8	4,990
12	10	1.0x	0	1.98	28.5	179	32.8	5,860
LSD 0.10				NS	3.2	NS	3.1	700
LSD 0.25				NS	1.4	NS	2.2	
		480						

† Compost rates were based on dry weight.
† The 1.0x fertilizer rate consisted of 160 lbs N, 90 lbs P_2O_5, 120 lbs K_2O, and 24 lbs S/A.
NS Denotes that the treatment means were not different at the indicated P levels.
§ Compost was applied in April of 1993 in the off-bar along with the fertilizer.

Table 3. F-values for effect of fertilizer and compost addition on first stubble yield parameters for a Baldwin silty clay soil at the Iberia Research Station in 1993.

Source	df	Stalk wt.	Population	CRS	Cane yield	Sugar yield
Fert. (F)	1	0.20	0.23	18.96***	30.81****	34.97****
Compost (C)	5	0.52	1.36	0.48	1.03	0.62
FXC	5	2.05°	0.31	3.24*	0.98	1.68°
% CV		11.32	4.39	3.15	7.81	9.56
RMSE		0.2497	1327	6.289	2.426	594.0

°,*,***, and **** denote statistical significance at the P≤0.25, 0.05, 0.001, and 0.0001 levels, respectively. Remaining F-values were not significant at P≤0.25.

Table 4. Effect of fertilizer and compost on first stubble yield parameters at Jeanerette in 1993.

T#	Compost†	Fert.‡	Millable stalk Wt.	Millable stalk No.	CRS	Cane yield	Sugar yield
	T/A		lbs	1000/A	lbs/T	T/A	lbs/A
1	0	0	2.07	30.3	196	26.4	5,180
2	0	1.0x	2.16	30.3	205	33.4	6,860
3	20	0	2.18	30.9	188	26.7	5,010
4	20	1.0x	2.26	31.0	212	33.3	7,080
5	40	0	2.38	29.9	193	28.3	5,470
6	40	1.0x	1.86	30.2	203	32.9	6,660
7	60	0	2.12	30.0	195	30.7	5,990
8	60	1.0x	2.34	29.1	202	33.2	6,690
9	80	0	2.43	31.1	198	30.0	5,930
10	80	1.0x	2.39	32.7	207	33.7	6,980
11	100	0	2.16	30.4	200	30.8	6,180
12	100	1.0x	2.33	29.4	196	33.3	6,520
LSD 0.10			NS	NS	9	NA	NS
LSD 0.25			0.24	NS	6	NA	570

† Compost rates were based on dry weight.

‡ The 1.0x fertilizer rate consisted of 160 lbs N, 90 lbs P_2O_5, 120 lbs K_2O, and 24 lbs S/A.

NA Denotes that the LSD value is not given because the compost x fertilizer interaction was not significant at the P≤0.25 level.

NS Denotes that the treatment means were not different at the indicated P levels.

Table 5. Effect of fertilizer on first stubble yield parameters at Jeanerette in 1993.

Fert.	Millable stalk Wt.	Millable stalk No.	CRS	Cane yield	Sugar yield
	lbs	1000/A	lbs/T	T/A	lbs/A
0	2.22	30.4	195	28.8	5,630
1.0x	2.19	30.2	204	33.3	6,800
LSD 0.10	NA	NS	NA	1.4	NA
LSD 0.25	NA	NS	NA	NS	NA

NS Denotes that fertilizer did not affect the yield parameter at the indicated P levels.
NA Denotes that the LSD value is not given because the compost x fertilizer interaction was statistically significant at the P≤0.25 level.

Table 6. Effect of compost on first stubble yield parameters at Jeanerette in 1993.

Compost	Millable stalk Wt.	Millable stalk No.	CRS	Cane yield	Sugar yield
T/A	lbs	1000/A	lbs/T	T/A	lbs/A
0	2.12	30.3	201	29.9	6,020
20	2.22	31.0	200	30.0	6,040
40	2.12	29.9	198	30.5	6,060
60	2.23	29.5	199	31.9	6,340
80	2.31	31.1	202	31.9	6,450
100	2.24	29.9	198	32.1	6,350
LSD 0.10	NS	NS	NA	NS	NA
LSD 0.25	NS	NS	NA	NS	NA

NS Denotes that compost did not affect the yield parameters at the indicated P levels.
NA Denotes that the LSD is not given because the compost x fertilizer interaction was significant at the P≤0.25 level.

Table 7. F-values for effect of fertilizer and compost addition on first stubble yield parameters for a Memphis silt loam soil at Youngsville in 1993.

Source	df	Stalk wt.	Population	CRS	Cane yield	Sugar yield
Fert. (F)	1	0.36	0.30	0.04	0.76	0.54
Compost (C)	5	0.92	0.90	0.97	0.40	0.30
FXC	5	1.42	2.68*	1.05	1.16	0.85
% CV		10.96	4.61	3.84	6.78	8.82
RMSE		0.2101	1444	7.856	1.990	529.4

* Denotes statistical significance at the P≤0.05 level. Remaining F-values were not significant at P≤0.25.

Table 8. Effect of fertilizer and compost on first stubble yield parameters at Youngsville in 1993.

T#	Compost†	Fert.†	Millable stalk Wt.	Millable stalk No.	CRS	Cane yield	Sugar yield
	T/A		lbs	1000/A	lbs/T	T/A	lbs/A
1	0	0	1.99	31.6	205	28.0	5,730
2	0	1.0x	1.97	31.5	208	29.9	6,240
3	15	0	1.90	33.5	205	29.5	6,070
4	15	1.0x	1.90	30.3	204	27.9	5,690
5	30	0	1.76	30.1	208	28.6	5,940
6	30	1.0x	2.06	31.1	204	29.6	6,040
7	45	0	1.99	31.4	212	28.6	6,070
8	45	1.0x	2.03	30.7	204	31.0	6,330
9	60	0	2.07	31.3	200	30.2	6,040
10	60	1.0x	1.79	31.4	201	28.7	5,760
11	75	0	1.67	30.1	195	29.4	5,770
12	75	1.0x	1.88	32.8	207	30.7	6,350
LSD 0.10			NS	2.0	NS	NS	NS
LSD 0.25			NS	1.4	NS	NS	NS

† Compost rates were based on dry weight.
† The 1.0x fertilizer rate consisted of 160 lbs N, 90 lbs P_2O_5, 120 lbs K_2O, and 24 lbs S/A.
NS Denotes that the treatment means were not different at the indicated P level.

Table 9. Effect of fertilizer on first stubble yield parameters at Youngsville in 1993.

Fert.	Millable stalk Wt.	Millable stalk No.	CRS	Cane yield	Sugar yield
	lbs	1000/A	lbs/T	T/A	lbs/A
0	1.90	31.3	204	29.0	5,940
1.0x	1.94	31.3	205	29.6	6,070
LSD 0.10	NS	NS	NS	NS	NS
LSD 0.25	NS	NS	NS	NS	NS

NS Denotes that the treatment means were not different at the indicated P levels.

Table 10. Effect of compost on first stubble yield parameters at Youngsville in 1993.

Compost	Millable stalk Wt.	Millable stalk No.	CRS	Cane yield	Sugar yield
T/A	lbs	1000/A	lbs/T	T/A	lbs/A
0	1.98	31.6	207	29.0	5,980
15	1.90	31.9	205	28.7	5,880
30	1.91	30.6	206	29.1	5,990
45	2.01	31.0	208	29.8	6,200
60	1.93	31.3	200	29.4	5,900
75	1.78	31.4	201	30.0	6,061
LSD 0.10	NS	NS	NS	NS	NS
LSD 0.25	NS	NS	NS	NS	NS

NS Denotes that the indicated variables was not different at the indicated P levels.

KENAF AND SUGARCANE RESEARCH ON FIBER PRODUCTION IN 1993

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in cooperation with
St. Gabriel Research Station

SUMMARY:

Experiments were conducted in 1993 to compare fiber production in Kenaf varieties and a wild sugarcane variety. In Kenaf, varieties EV 71, Cubano and Tainung 2 were tested with 0-0-0, 80-0-0, 160-0-0, and 160-40-80 NPK fertilizer rates. The EV 71 and Tainung 2 varieties produced higher fiber yields than Cubano. The 80-0-0 fertilizer rate increased yields of each variety, but higher rates did not improve yield. In sugarcane, a wild cane type variety L79-1002 was tested with 0-0-0, 160-0-0, and 160-60-120 NPK fertilizer rates. The 160-0-0 rate increased fiber yield, but the higher rate did not improve yield. The highest average yields of dry fiber produced were 11.6 T/A in Kenaf and 10.1 T/A in the wild cane. In addition to fiber, the cane produced 4433 lbs/A of sugar. The Kenaf contained bast and core fibers, and the cane contained typical bagasse fiber.

OBJECTIVES:

The research was initiated to evaluate the potential of growing Kenaf and high-fiber sugarcane as alternate crops for the production of fiber.

RESULTS AND DISCUSSION:

The following experiments were located on a Commerce soil on the St. Gabriel Research Station.

Kenaf Fiber Production

An experiment was conducted to test the effects of rates of fertilizer application with different varieties of Kenaf. The rates tested were 0-0-0, 80-0-0, 160-0-0, and 160-40-80 lbs/A of NPK fertilizers. The varieties tested with each rate were EV 71, Cubano, and Tainung 2. The fertilizer treatments were bedded in the rows prior to planting. The Kenaf plots were planted in two drills, 22 inches apart on sugarcane size rows six feet wide. The seeding rate was 80,000 seeds per acre. Prowl was applied as a pre-emergence herbicide at planting time to control weeds. The plots were planted on April 27 and the crop was cut with a sugarcane harvester in November, 1993. All the stalks on each plot were weighed in the field. The drill and row spacings were chosen to accommodate sugarcane harvesting equipment so that the crop could be cut, weighed and loaded mechanically at harvest time.

The stalk yield, average stalk weight, and percent fiber in the stalks were measured at harvest time. The percent bast and core fibers in the stalks were determined by crushing 10-

stalk samples in a sugarcane laboratory mill and separating the fibers by hand. The percent and yield per acre of bast and core fibers were calculated for each plot.

The data obtained on the yield components of each variety and fertilizer treatment are reported in Table 1. The EV 71 and Tainung 2 varieties produced similar average stalk yields and fiber yields but higher than in Cubano. The average stalk weight was higher in Cubano than in the other varieties. The 80-0-0 NPK fertilizer increased the stalk and fiber yields, but the higher fertilizer rates did not improve yields.

The data obtained on the yield of bast and core fibers are reported in Table 2. Variety Tainung 2 was lower in percent core fiber than the other varieties. However, EV 71 and Tainung 2 produced more total bast and core fibers per acre than Cubano. As an average of varieties, the 80-0-0 NPK fertilizer increased the bast and core fiber yields, but higher rates did not improve yield.

Sugarcane Fiber and Sugar Production

An experiment was conducted to test the effects of fertilizer rates on the fiber and sugar production of a wild cane variety L79-1002. This cane variety is a progeny from crossing CP52-68 X Tianan 96. CP52-68 was a major variety grown in Louisiana in the 1960's and Tianan 96 is a wild type of sugarcane which grows without cultivation in Argentina. Variety L79-1002 is a high fiber cane with a high stalk population, small stalk diameter and high stubbling ability.

Variety L79-1002 was planted in replicated plots and the fertilizer treatments were applied in plant cane in 1992 and first stubble in 1993. The rates tested consisted of 0-0-0, 160-0-0 and 160-60-120 lbs/A of NPK. The treatments were applied in the spring and normal cane cultural practices were used during the growing season. The cane was cut with a cane harvester and weighed in November to measure the fiber, cane, and sugar yields. The stalk population and weight were determined at harvest time. A 20-stalk sample from each plot was used to measure the percent fiber and sucrose in the laboratory.

The data obtained in this test are reported in Table 3. The stalk population was very high and the average stalk weight was relatively low on each plot as compared to a commercial cane variety. The N and NPK fertilizer treatments increased the stalk population, average stalk weight, fiber, cane and sugar yields, but the differences between the fertilizer rates were small. The highest yields produced were 41.5 T/A of cane stalks containing 24.3% fiber and 10.1 T/A of dry fiber. Also, the cane stalks contained 6.4% sucrose and produced 4433 pounds of sugar per acre.

Kenaf and Cane Fiber Comparison

The highest average yields of dry fiber produced were 11.6 T/A in Kenaf and 10.1 T/A in the wild sugarcane. The fiber yields were similar in each crop, but the types of fiber in kenaf and cane were different. Kenaf contained about one-third bast fiber and two-thirds core fiber. Bast fiber is long and strong individual fibers and core fiber is soft and spongy fiber contained in the inter-core of the stalks. The cane fiber was typical bagasse fiber generally used to burn

and generate power in sugar mills. However, in addition to fiber, the wild cane produced up to 4433 lbs/A of sugar equal to about one-half the sugar yields of commercial varieties.

The Kenaf varieties and the wild cane variety were considerably taller than the maximum topping height of a cane harvester and the fiber yields reported were lower than the yields actually produced in the field.

Table 1. Effect of varieties and fertilizer rates on the yield components of Kenaf grown on a Commerce soil on the St. Gabriel Research Station, 1993.

Kenaf Variety	Fertilizer $N-P_2O_5-K_2O$	Stalk Yield	Stalk Weight	Stalk Fiber	Fiber Yield
	lbs/A	T/A	lbs	%	T/A
EV 71	0-0-0	23.6	0.52	40.0	9.5
	80-0-0	33.4	1.12	38.8	13.0
	160-0-0	27.3	1.14	40.2	11.0
	160-40-80	26.8	1.01	40.1	10.7
Cubano	0-0-0	16.2	0.72	38.6	6.2
	80-0-0	26.6	1.20	37.9	10.1
	160-0-0	28.5	1.38	39.6	11.3
	160-40-80	25.2	1.88	37.5	9.4
Tainung 2	0-0-0	20.1	0.80	40.6	8.1
	80-0-0	25.1	0.76	41.0	10.3
	160-0-0	28.3	1.49	43.9	12.4
	160-40-80	30.4	0.73	42.1	12.8
LSD .05 Treatment		5.6			2.7
		Mean Effect			
EV 71		27.8	0.95	39.8	11.0
Cubano		24.1	1.30	38.4	9.3
Tainung 2		26.0	0.95	41.9	11.0
	0-0-0	20.0	0.68	39.7	7.9
	80-0-0	28.4	1.03	39.2	11.1
	160-0-0	28.0	1.34	41.2	11.6
	160-40-80	27.5	1.21	39.9	11.0
LSD .05 Variety		2.8			1.1
LSD .05 Fertilizer		3.2			1.3

Table 2. Effect of varieties and fertilizer rates on the fiber yield of Kenaf grown on a Commerce soil on the St. Gabriel Research Station, 1993.

Kenaf Variety	Fertilizer $N-P_2O_5-K_2O$	Dry Fiber Yield			
		Bast Fiber		Core Fiber	
	lbs/A	%	T/A	%	T/A
EV 71	0-0-0	38.9	3.7	61.1	5.8
	80-0-0	36.4	4.7	63.6	8.3
	160-0-0	37.1	4.1	62.9	6.9
	160-40-80	32.4	3.5	67.6	7.2
Cubano	0-0-0	40.9	2.6	59.1	3.7
	80-0-0	36.1	3.6	63.9	6.5
	160-0-0	33.3	3.8	66.7	7.5
	160-40-80	31.5	3.0	68.5	6.5
Tainung 2	0-0-0	34.6	2.8	65.4	5.3
	80-0-0	36.4	3.7	63.6	6.6
	160-0-0	30.0	3.7	70.0	8.7
	160-40-80	29.3	3.8	70.7	9.0
LSD .05 Treatment			0.8		1.5
		Mean Effect			
EV 71		36.2	4.0	63.8	7.1
Cubano		35.5	3.2	64.6	6.0
Tainung 2		32.6	3.5	67.4	7.4
	0-0-0	38.1	3.0	61.9	4.9
	80-0-0	36.3	4.0	63.7	7.1
	160-0-0	33.5	3.9	66.5	7.7
	160-40-80	31.1	3.4	68.9	7.6
LSD .05 Variety			0.4		0.7
LSD .05 Fertilizer			0.5		0.8

Table 3. Effect of fertilizers on the fiber and sugar yields of a wild cane variety L79-1002 on a Commerce soil in 1993.

Fertilizer N-P-K	Stalk		Dry Stalk Fiber Yield		Cane Yield	Stalk Sucrose	Sugar Yield
	No.	Wt.					
lbs/A	1000/A	lbs	%	T/A	T/A	%	lbs/A
0-0-0	62.9	0.73	26.5	5.9	22.5	5.5	1993
160-0-0	95.5	0.86	23.9	9.7	40.9	5.9	3804
160-60-120	89.8	0.93	24.3	10.1	41.5	6.4	4433
LSD .05	11.6	0.13	NS	1.7	5.6	NS	1253

Sucrose is expressed as percent of stalk weight. Variety L79-1002 is an F_1 progeny from crossing CP52-68 X Tianan 96 (a wild type cane from Argentina).

1993 ASI FINAL MOLASSES SURVEY

ASI Staff
Audubon Sugar Institute

During the 1993 sugarcane harvest season, weekly composites of final molasses samples were sent to Audubon for analysis. The people involved and their responsibilities were as follows:

Freddie Martin Wally Millet Gert Hawkins	Dilution of final molasses samples
Steve Clarke Monica Fontenot	Refractometer Brix and Pol analysis
Don Day Durriya Sarkar	Conductivity Ash
Michael Saska Mei Wu	Sugars analyzed by HPLC
Harold Birkett Jeanie Stein	Mailing survey bottles to factories; Calculation of data and communicating results to factories.

Samples were analyzed for refractometer Brix, pol, sucrose, glucose, fructose, and conductivity ash. From these analyses true purity, target purity, total sugars and total sugars as invert were calculated.

Results of the state average by week are given in Table 1 and shown in Figure 1. Results of the crop average for each factory are given in Table 2 and shown in Figure 2. Figure 3 shows results of the crop average for each factory in ascending order. Figure 4 shows results of the crop average for the past three years.

After the crop each factory's weekly samples were combined into two composites, one for each half of the crop. We would like to thank Mr. Hershel Morris and his staff at Feed & Fertilizer for kindly doing the elemental analyses on these molasses composites. Table 3 shows the results of the elemental analyses.

This project was partially funded by the American Sugar Cane League.

Equipment Used for Analyses:

Apparent Purity:

Bellingham & Stanley Refractometer - Model RFM 90.
Rudolph Autopol IIS Saccharimeter.

Conductivity Ash:

Radiometer Copenhagen.

Sugars by HPLC:

Column:	Bio-Rad HPX-87 300 X 7.8 mm at 85 deg. C.
Solvent:	0.01 M K_2SO_4.
Detector:	Waters 410 Differential Refractometer.
Integrator:	Spectra-physics SP4270 Integrator.
Pump:	Waters Associate Chromatography Pump, Model-6000A, SDS 10452.

List of Formulas Used:

Conductivity Ash = 0.0084 K C + 0.8
where K = cell constant (0.99 cm^{-1})
C = measured conductivity in microsiemens.

True Solids = 1 / (101.3 / Refractometer Brix + 0.932 / Sucrose) X 100

Target Purity = 42.4 - 12.3 log (Reducing Sugars by HPLC / Conductivity Ash)

Table 1

1993 ASI FINAL MOLASSES SURVEY RESULTS

WEEK BY WEEK SUMMARY

W. E.	Ref. Brix	App. Purity	Glu-cose	Fruc-tose	Red. Sugars	Cond. Ash	RS/ Ash	True Solids	True Sucrose	True Purity	Target Purity	Diff.	Total Sugars	Tot.Sug. Invert
10/09/93	82.2	33.88	6.04	8.93	14.97	12.96	1.17	79.42	35.03	44.09	41.69	2.39	50.01	51.85
10/16/93	82.6	33.91	6.22	9.22	15.43	13.23	1.17	79.77	34.93	43.79	41.60	2.19	50.36	52.20
10/23/93	82.4	34.83	5.41	8.37	13.78	13.49	1.03	79.66	34.99	43.94	42.36	1.57	48.78	50.62
10/30/93	82.7	35.08	4.98	7.94	12.92	14.20	0.92	79.83	34.18	42.82	42.98	-0.15	47.11	48.90
11/06/93	82.2	33.94	5.19	8.30	13.49	14.37	0.95	79.35	34.02	42.88	42.80	0.09	47.51	49.30
11/13/93	82.2	33.11	5.28	8.82	14.09	14.72	0.97	79.39	34.42	43.36	42.70	0.66	48.52	50.33
11/20/93	81.8	32.96	5.42	9.02	14.44	14.30	1.02	79.00	33.86	42.86	42.40	0.46	48.30	50.08
11/27/93	81.6	33.11	4.92	7.99	12.92	15.15	0.86	78.76	33.62	42.69	43.30	-0.60	46.54	48.31
12/04/93	81.6	33.72	4.74	7.87	12.61	15.65	0.81	78.80	34.61	43.92	43.61	0.31	47.22	49.04
12/11/93	82.1	34.21	3.87	8.03	11.90	15.79	0.77	79.41	37.72	47.52	44.04	3.48	49.62	51.61
12/18/93	82.5	34.31	3.13	7.62	10.75	16.62	0.65	79.89	39.78	49.82	44.97	4.85	50.53	52.62
12/25/93	83.6	36.98	2.15	5.65	7.80	17.43	0.46	80.95	40.25	49.74	47.61	2.13	48.05	50.17
1/01/94	85.2	43.33	2.20	7.20	9.40	16.39	0.57	82.87	52.50	63.35	45.37	17.98	61.90	64.66
Average	82.5	34.87	4.58	8.07	12.65	14.95	0.87	79.78	36.92	46.21	43.49	2.72	49.57	51.51

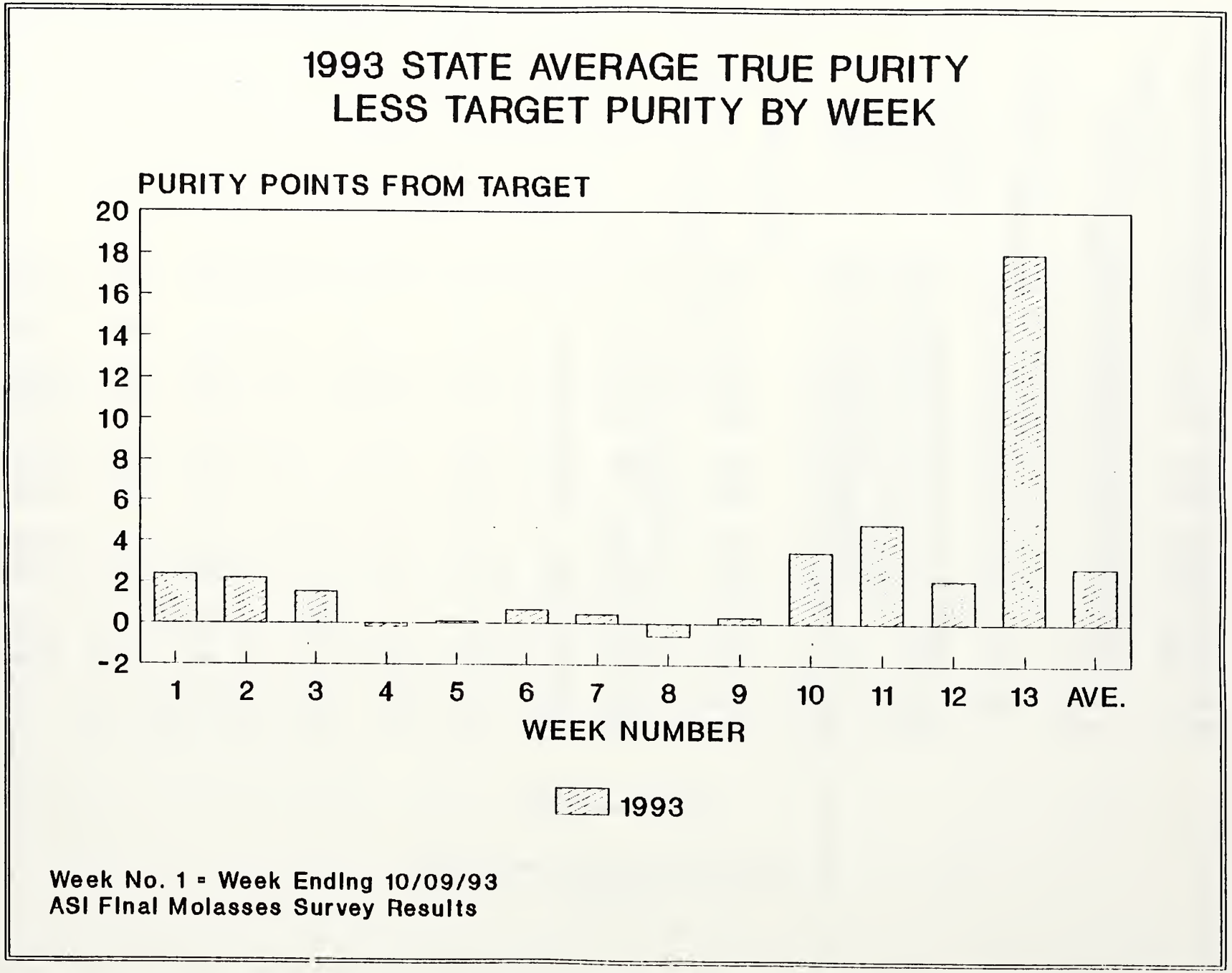

1993 STATE AVERAGE TRUE PURITY
LESS TARGET PURITY BY WEEK
PURITY POINTS FROM TARGET
20
18
16
14
12
10
8
6
4
2
0
-2
1
2
3
4
5
6
7
8
9
10
11
12
13
AVE.
WEEK NUMBER
1993
Week No. 1 = Week Ending 10/09/93
ASI Final Molasses Survey Results

FIGURE 1

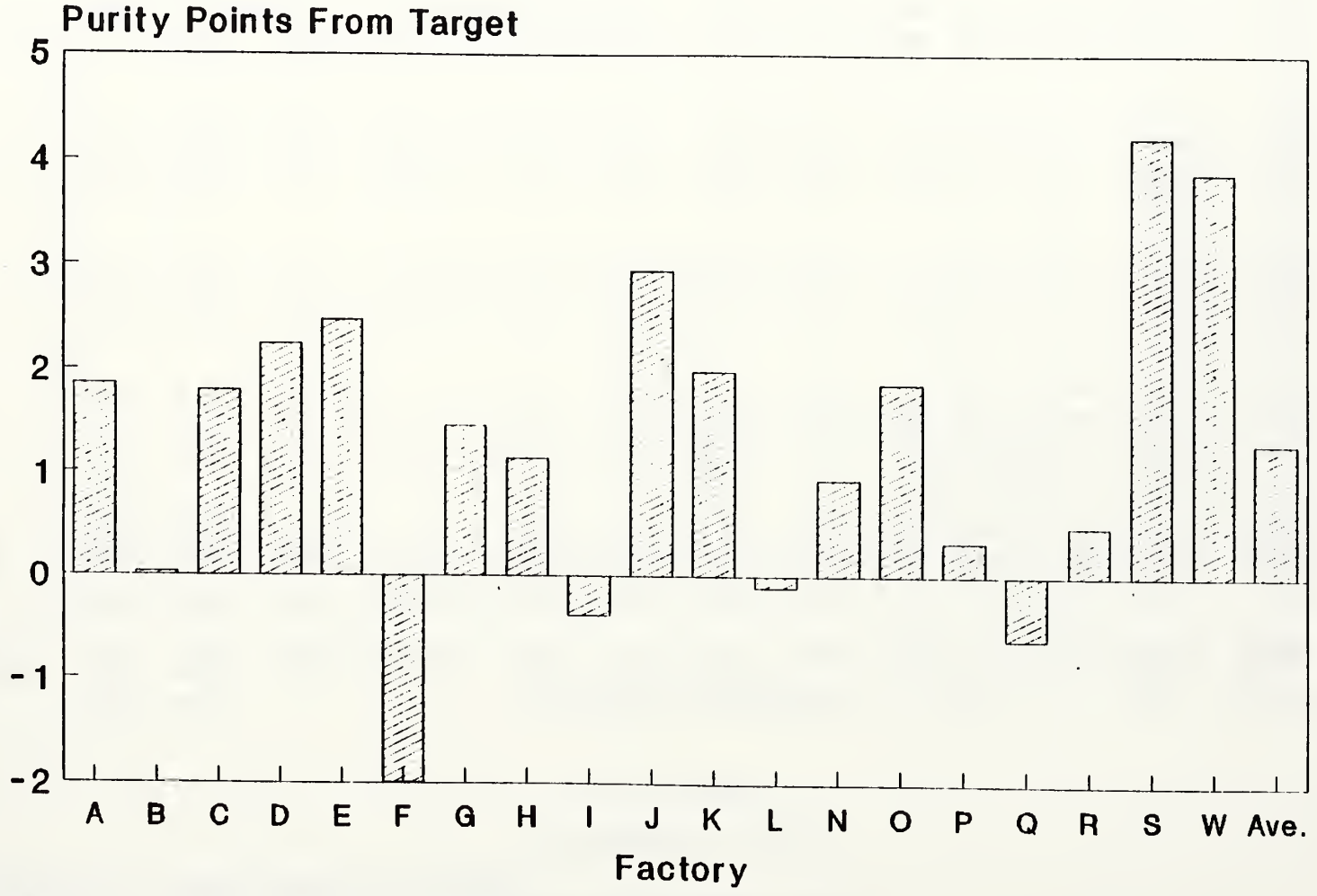
TABLE 2

1993 ASI FINAL MOLASSES SURVEY

CROP AVERAGE BY FACTORY

Factory	Ref. Brix	App. Pty.	Glu.	Fruc.	RS	Cond. Ash	RS/ Ash	True Solids	True Suc.	True Pty.	Target Pty.	Diff.	Total Sugars	Ttl.Sug. Invert
A	82.2	34.00	6.64	8.81	15.46	13.21	1.18	79.37	34.46	43.41	41.56	1.85	49.91	51.73
B	80.1	34.24	4.26	7.35	11.61	14.84	0.79	77.34	33.84	43.75	43.72	0.03	45.45	47.23
C	81.1	31.71	6.03	9.17	15.20	13.58	1.13	78.29	34.14	43.63	41.84	1.79	49.34	51.14
D	82.4	36.60	4.29	7.08	11.38	15.43	0.74	79.67	36.91	46.30	44.06	2.24	48.28	50.22
E	86.5	32.12	7.10	10.47	17.57	13.16	1.34	83.56	36.20	43.32	40.84	2.47	53.77	55.67
F	84.1	30.37	5.60	9.07	14.66	15.39	0.97	81.08	32.98	40.67	42.67	-1.99	47.64	49.38
G	82.3	33.43	6.26	9.06	15.32	13.56	1.13	79.48	34.34	43.21	41.76	1.45	49.66	51.46
H	83.4	33.38	6.46	9.57	16.03	14.36	1.13	80.54	34.58	42.93	41.80	1.13	50.61	52.43
I	82.1	32.51	5.01	8.51	13.53	14.90	0.92	79.31	33.72	42.52	42.91	-0.39	47.25	49.02
J	84.8	36.36	4.91	7.92	12.83	15.55	0.83	82.02	38.05	46.38	43.44	2.94	50.87	52.88
K	80.3	35.28	5.04	7.99	13.02	14.70	0.91	77.59	34.97	45.07	43.08	1.98	47.99	49.83
L	78.5	36.54	2.96	5.79	8.74	15.89	0.55	75.86	34.56	45.52	45.64	-0.11	43.30	45.12
N	82.0	33.96	4.64	8.54	13.17	14.52	0.92	79.19	34.74	43.86	42.93	0.93	47.91	49.74
O	84.4	33.01	5.96	9.86	15.83	13.18	1.21	81.52	35.28	43.28	41.42	1.86	51.10	52.96
P	81.2	30.90	4.95	9.03	13.98	14.18	1.00	78.37	33.57	42.84	42.51	0.33	47.55	49.32
Q	81.1	31.87	4.39	8.44	12.83	14.48	0.90	78.26	33.23	42.44	43.06	-0.61	46.07	47.82
R	81.0	30.52	4.96	9.23	14.19	13.89	1.04	78.20	33.50	42.88	42.39	0.48	47.69	49.45
S	83.6	38.51	3.43	6.75	10.18	16.27	0.64	80.99	40.07	49.44	45.22	4.22	50.24	52.35
W	81.2	38.97	3.61	6.71	10.32	15.38	0.68	78.57	38.10	48.46	44.58	3.88	48.42	50.43

STATE AVERAGE VS. INDIVIDUAL FACTORIES
TRUE PURITY LESS TARGET PURITY



1993 ASI Final Molasses Survey Results

FIGURE 2

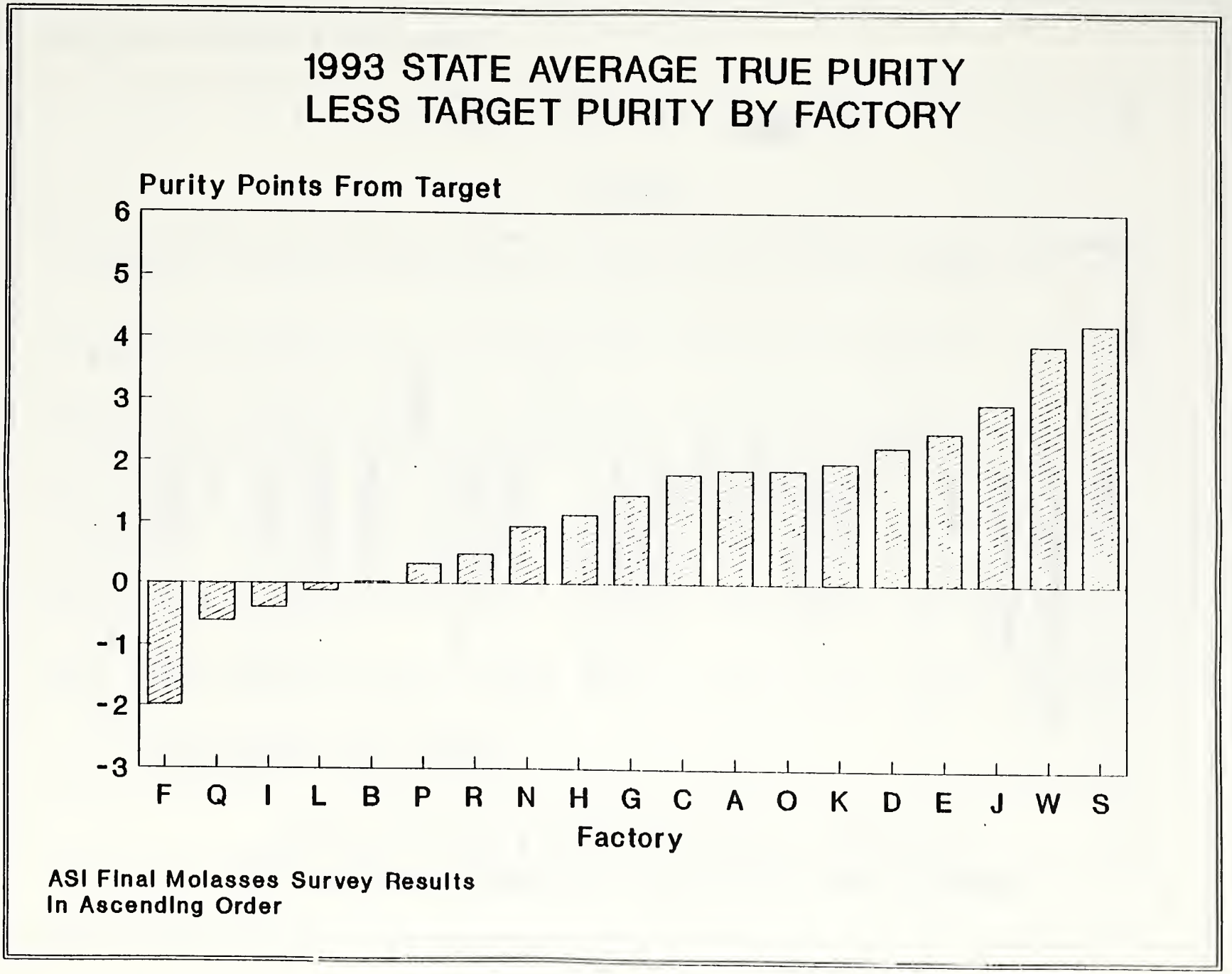

1993 STATE AVERAGE TRUE PURITY
LESS TARGET PURITY BY FACTORY
Purity Points From Target
6
5
4
3
2
1
0
-1
-2
-3
F Q I L B P R N H G C A O K D E J W S
Factory
ASI Final Molasses Survey Results
In Ascending Order

FIGURE 3

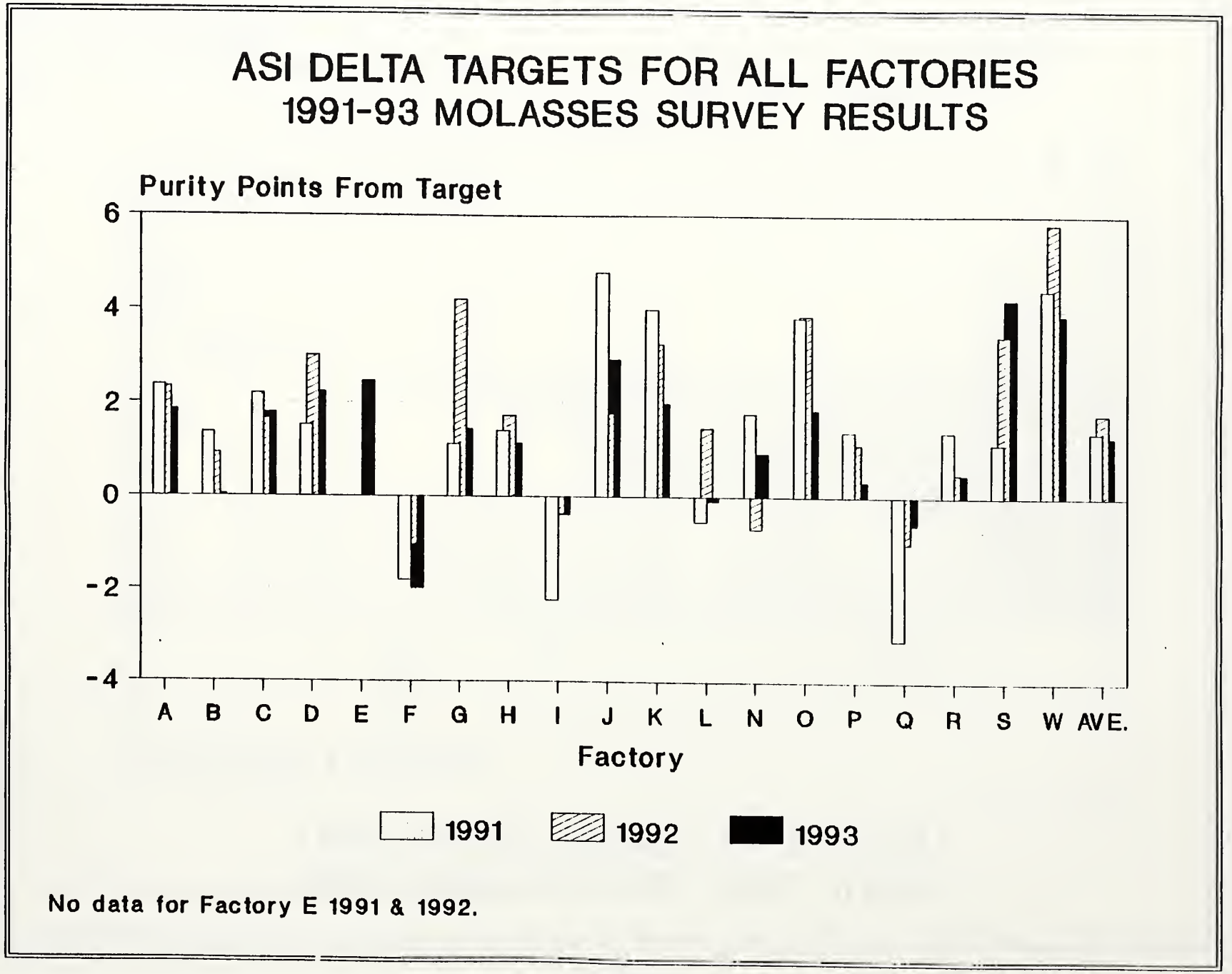

ASI DELTA TARGETS FOR ALL FACTORIES
1991-93 MOLASSES SURVEY RESULTS
Purity Points From Target
6
4
2
0
-2
-4
A B C D E F G H I J K L N O P Q R S W AVE.
Factory
1991
1992
1993
No data for Factory E 1991 & 1992.

FIGURE 4

Table 3

1993 ELEMENTAL ANALYSIS BY FEED & FERTILIZER

ASI FINAL MOLASSES SURVEY

	%						ppm		
Factory	Potassium	Chloride	Calcium	Sulfur	Magnesium	Silica	Phosphorus	Sodium	Iron
A - 1	2.11	0.79	0.707	0.222	0.332	0.371	885	328	110
A - 2	2.64	0.71	0.843	0.263	0.374	0.288	781	468	113
B - 1	2.60	1.21	0.695	0.410	0.404	0.134	778	432	103
B - 2	2.61	0.65	0.730	0.467	0.393	0.447	766	304	120
C - 1	3.98	0.91	0.592	0.330	0.345	0.341	815	219	81
C - 2	2.79	0.85	0.588	0.419	0.342	0.348	777	267	122
D - 1	2.74	1.96	0.797	0.374	0.651	0.246	875	466	148
D - 2	3.24	2.27	0.783	0.413	0.676	0.207	792	330	124
E - 2	3.31	0.54	0.625	0.270	0.398	0.245	947	727	185
F - 1	3.91	1.89	0.829	0.370	0.653	0.338	798	702	131
F - 2	2.09	2.77	0.824	0.445	0.671	0.145	901	615	124
G - 1	2.30	1.03	0.663	0.422	0.416	0.393	884	280	117
G - 2	2.31	1.12	0.648	0.457	0.391	0.314	866	306	149
H - 1	2.84	1.20	0.714	0.347	0.431	0.257	883	265	130
H - 2	3.56	1.62	0.809	0.434	0.474	0.247	676	379	141
I - 1	2.19	2.13	0.700	0.315	0.561	0.278	805	477	98
I - 2	2.68	2.41	0.801	0.438	0.664	0.095	861	563	91
J - 1	3.11	1.92	0.663	0.401	0.547	0.292	917	327	127
J - 2	3.11	2.29	0.748	0.450	0.601	0.096	948	499	90
K - 1	2.89	1.04	0.693	0.431	0.426	0.585	629	648	178
K - 2	4.66	1.66	0.814	0.492	0.484	0.293	723	535	99
L - 1	3.60	1.88	0.935	0.349	0.541	0.395	625	1257	130
L - 2	3.87	2.04	0.929	0.448	0.588	0.242	741	1384	108
N - 1	3.70	1.62	0.731	0.319	0.529	1.580	977	561	195
N - 2	2.89	2.04	0.747	0.408	0.584	0.186	908	717	122
O - 1	2.61	0.44	0.508	0.248	0.374	0.289	841	1448	82
O - 2	1.80	1.24	0.533	0.291	0.358	0.199	723	1636	78
P - 1	2.86	0.84	0.752	0.400	0.466	0.229	882	330	184
P - 2	3.75	1.55	0.863	0.451	0.442	0.384	731	294	189
Q - 1	3.44	0.94	0.600	0.449	0.408	0.234	1141	828	143
Q - 2	2.33	1.39	0.643	0.492	0.444	0.298	966	897	116
R - 1	2.21	0.93	0.615	0.391	0.356	0.255	645	851	126
R - 2	2.39	1.05	0.677	0.459	0.386	0.238	793	764	119
S - 1	2.47	2.51	0.809	0.441	0.627	0.203	626	901	92
S - 2	2.98	2.80	0.858	0.537	0.698	0.290	700	1010	82
W - 1	3.72	2.10	0.762	0.269	0.579	0.238	805	1077	159
W - 2	2.08	2.45	0.827	0.341	0.648	0.245	838	1741	102

1993 MILLING TESTS

Harold Birkett and Jeanie Stein
Audubon Sugar Institute

During the 1993 crop twelve milling tests were conducted at 11 factories. Prepared cane and bagasse samples from each mill in the tandem were collected. These samples were analyzed for pol, moisture, fiber, and ash content using standard methods. Moisture % bagasse, pol % bagasse, and individual and cumulative pol extractions were determined for each mill tested. In all but one test, preparation index of prepared cane was determined. In addition, at four factories the % open cells throughout the tandem was also determined.

The % open cells was measured by first dividing a sample into two subsamples. One subsample was washed for 30 minutes using a tumbler turning at approximately 19 rpm while the other sample was digested using a Waring blender for 5 minutes. Both samples were made up to have the same sample to water ratio of 10:1. The percentage of open cells was calculated as the difference between the digested pol % fiber and the washed pol % fiber divided by the pol % fiber in cane expressed as a percent.

Results

Results of each factory's moisture % bagasse, pol % bagasse, fiber % bagasse, ash % bagasse, individual mill extraction, cumulative pol extraction, and % open cells are given in Tables 1 through 7 and are summarized in Table 8.

Figures 1 through 4 show moisture % bagasse vs mill number for 4-, 5-, 6-, and 7-mill tandems. A plot of moisture % bagasse for each mill in a tandem is a good way of indicating which mills are working well and which could be improved. The plot should be concave with each succeeding mill showing a lower moisture value.

A factory with a 4-mill tandem is presented in Figure 1. It shows mill 3 moisture as higher than that of mill 2 indicating a need for improvement at mill 3. Factories shown in Figure 2 have five mills in a tandem. It is easy to see that the moisture % bagasse on all three second mills are higher than desired. Figures 3 and 4 show similar results to that of figures 1 and 2. All tandems shown in these four plots have one or more mills needing improvement.

Figure 5 shows the moisture % bagasse vs mill position. This is a normalized curve of all 70 data points collected in 1993 and shows the average plot to be almost linear. A good moisture plot would not be linear but concave, as was the average plot for moisture data collected over the previous seven years.

Fiber % bagasse for a 4-mill tandem is shown in Figure 6. Fiber % bagasse should be increasing with every mill. In this plot mill 3 fiber is less than that of mill 2, indicating as in the moisture plot that mill 3 is not working as well as it could. Figures 7, 8, and 9 show similar results for tandems with 5-, 6-, and 7- mills respectively. Factory C shown in Figure 7 seems to have achieved good work with mill 3 as indicated by a higher fiber than that for mill 4.

Figure 10 shows the average plot for fiber % bagasse vs mill position for all factories tested.

Figures 11 through 14 show the individual mill pol extraction for each mill in 4-, 5-, 6-, and 7-mill tandems. A good extraction for first mills would be between 50-60%. A good last mill extraction would range from 40-50%. In-between mills usually average about 30%.

All first mill extractions measured in 1993 are shown in Figure 15. Average extraction for first mills was 50% with Factory C showing a high of 64.45%. Last mill extractions are shown in Figure 16. Values ranged from about 23 to 50%. The average was about 35% with Factory I showing a high of 50.63%. Data for 1993, as in past years, shows that first and last mills receive the most attention.

Figures 17 through 20 show cumulative pol extractions for 4-, 5-, 6-, and 7-mill tandems. As seen in all of these plots, the mills not working well are the same as those indicated in the previous moisture and fiber plots. Figure 21 shows the average plot for all extraction points. The shape of the pol extraction curve is convex, as would be expected.

Figure 22 shows the % open cells throughout tandems at four factories. As shown, regardless of the preparation index, by mill 4 almost 97% of cells are opened and by the last mill approximately 99% of cells have been opened. Figure 23 shows the preparation index of prepared cane vs pol extraction of corresponding first mill. There is a slight positive trend but it is statistically insignificant ($r=0.13$).

Conclusion

In conclusion, the twelve milling tests conducted in 1993 was only the initial phase of a possible three-year milling project where more cane preparation and mill extraction tests will be done. Investigation of pressure-density relationships in connection with mill settings is also planned.

This project was funded by the American Sugar Cane League.

Table 1

Moisture % Bagasse

	Mill Number							
Factory	PC	1	2	3	4	5	6	7
K-1	73.60	61.43	57.98	59.59	53.82			
D-1	72.78	65.73	67.25	60.22	60.56	57.43		
C-1	69.14	58.58	62.86	58.34	56.12	53.03		
Q-1	72.73	59.68	63.12	60.43	52.78	51.94		
I-1	75.03	65.28	62.24	57.43	61.85	60.37	52.73	
W-1	71.18	68.99	63.27	62.31	60.22	56.17	57.99	
G-1	70.88	62.50	56.98	54.26	58.14	56.03	53.39	
A-1	73.50	65.65	59.76	54.95	53.72	55.35	53.07	
O-1	73.07	64.07	62.12	59.16	59.21	61.25	52.63	
B-1	73.83	67.90	58.89	60.05	59.77	59.31	59.91	53.50
B-2	71.51	62.49	56.24	57.54	58.70	58.17	56.58	52.04
S-1	73.55	67.31	66.26	65.99	63.38	60.91	58.60	55.84

Table 2

Pol % Bagasse

	Mill Number							
Factory	PC	1	2	3	4	5	6	7
K-1	10.21	8.04	6.40	5.74	4.68			
D-1	12.30	9.82	8.98	6.96	5.85	3.89		
C-1	12.16	9.42	7.21	5.08	3.71	2.76		
Q-1	11.32	8.81	6.93	4.56	3.62	2.92		
I-1	10.09	8.62	7.58	6.39	5.12	4.62	2.84	
W-1	12.14	11.53	10.06	8.93	8.36	6.10	4.71	
G-1	12.42	10.07	7.51	6.52	5.56	4.16	3.32	
A-1	11.07	10.79	8.05	6.49	4.90	3.65	2.45	
O-1	11.66	9.89	7.53	6.23	5.10	3.64	2.81	
B-1	9.37	8.32	6.64	5.49	4.18	3.81	2.61	2.21
B-2	12.14	9.81	8.28	7.69	6.22	4.59	3.41	2.65
S-1	10.04	8.57	6.92	6.19	5.10	2.86	2.41	1.53

Table 3

Fiber % Bagasse

	Mill Number							
Factory	PC	1	2	3	4	5	6	7
K-1	12.33	26.11	29.78	29.12	35.10			
D-1	12.27	21.02	20.65	29.19	28.53	32.32		
C-1	12.22	26.62	24.46	31.67	34.53	38.90		
Q-1	13.85	27.68	24.84	29.93	37.27	39.14		
I-1	12.90	23.70	27.55	31.85	30.14	30.54	38.13	
W-1	14.53	18.07	24.72	26.33	28.67	33.45	34.58	
G-1	14.30	24.10	29.85	32.43	31.31	32.95	37.30	
A-1	12.27	19.14	26.91	32.82	34.53	35.05	39.66	
O-1	11.66	21.96	26.78	30.12	30.72	31.12	40.62	
B-1	11.75	19.00	27.07	27.66	28.61	29.20	31.28	35.57
B-2	12.77	21.86	27.65	28.90	27.49	30.97	33.31	38.35
S-1	13.97	19.65	23.05	22.25	27.90	31.33	34.39	37.30

Table 4

Ash % Bagasse

	Mill Number							
Factory	PC	1	2	3	4	5	6	7
K-1	1.47	2.11	3.04	2.95	3.50			
D-1	1.06	1.45	1.47	1.60	1.47	1.75		
C-1	1.35	2.16	1.60	1.88	2.16	2.01		
Q-1	0.69	1.27	1.19	1.41	2.09	2.29		
I-1	1.05	1.25	1.68	1.64	1.49	1.36	3.31	
W-1	0.76	0.81	0.92	1.06	1.06	1.62	1.15	
G-1	1.62	1.71	2.35	2.58	2.12	2.26	2.51	
A-1	1.25	1.22	1.74	1.99	1.94	1.81	1.83	
O-1	0.80	0.94	1.12	1.12	1.14	1.22	1.36	
B-1	2.98	2.98	3.83	3.71	3.38	3.50	4.29	4.40
B-2	1.43	2.11	2.64	2.73	2.87	3.49	3.88	3.98
S-1	0.90	1.10	1.24	1.13	1.29	1.32	1.25	1.41

Table 5

Individual Mill Extraction

	Mill Number						
Factory	1	2	3	4	5	6	7
K-1	62.82	30.22	8.35	32.32			
D-1	53.41	6.90	45.17	14.00	41.36		
C-1	64.45	16.64	45.59	33.02	34.03		
Q-1	61.09	12.31	45.38	36.29	23.09		
I-1	53.50	24.31	27.13	15.35	11.01	50.63	
W-1	23.58	36.21	16.67	14.09	27.43	25.33	
G-1	51.89	39.77	20.08	11.76	28.84	29.62	
A-1	37.54	46.95	33.86	28.22	26.57	40.67	
O-1	54.96	37.56	26.47	19.73	29.55	40.88	
B-1	45.09	43.99	19.04	26.45	10.56	36.07	25.46
B-2	52.79	33.27	11.19	14.95	34.54	30.84	32.53
S-1	39.33	31.17	7.26	34.32	50.05	23.22	41.51

Table 6

Cumulative Pol Extraction

	Mill Number						
Factory	1	2	3	4	5	6	7
K-1	62.82	74.05	76.22	83.91			
D-1	53.41	56.63	76.22	79.55	88.01		
C-1	64.45	70.36	83.87	89.20	92.87		
Q-1	61.09	65.88	81.36	88.13	90.87		
I-1	53.50	64.80	74.35	78.29	80.68	90.46	
W-1	23.58	51.25	59.38	65.10	78.16	83.69	
G-1	51.89	71.02	76.84	79.57	85.46	89.77	
A-1	37.54	66.87	78.09	84.27	88.45	93.15	
O-1	54.96	71.88	79.32	83.40	88.30	93.09	
B-1	45.09	69.24	75.10	81.68	83.62	89.53	92.19
B-2	52.79	68.50	72.03	76.21	84.42	89.23	92.73
S-1	39.33	58.24	61.27	74.56	87.29	90.24	94.29

Table 7

% Open Cells

	Mill Number							
Factory	PC	1	2	3	4	5	6	7
K-1	83.31							
D-1	72.00							
C-1	82.68							
Q-1	81.55	91.26	96.42	97.39	99.09	99.31		
I-1	-							
W-1	81.40							
G-1	74.43							
A-1	72.29	80.40	91.79	94.76	97.33	98.60	99.38	
O-1	85.80	91.45	93.75	95.20	96.70	98.39	99.05	
B-1	77.79							
B-2	81.49	91.50	94.17	94.83	97.12	97.92	98.60	98.71
S-1	87.30							

Table 8

SUMMARY OF 1993 MILL TESTS

Factory	Prep. Index	Pol % Cane	Fiber % Cane	Moist % Bag.	Pol % Bag.	Pol Ext.	Ash % Bag.	Ash % Bag.
K-1	83.31	10.21	12.33	53.82	4.68	83.91	1.47	3.50
D-1	72.00	12.30	12.27	57.43	3.89	88.01	1.06	1.75
C-1	82.68	12.16	12.22	53.03	2.76	92.87	1.35	2.01
Q-1	81.55	11.32	13.85	51.94	2.92	90.87	0.69	2.29
I-1	-	10.09*	12.90*	52.73	2.84	90.46	1.05*	3.31
W-1	81.40	12.14	14.53	57.99	4.71	83.69	0.76	1.15
G-1	74.43	12.42	14.30	53.39	3.32	89.77	1.62	2.51
A-1	72.29	11.07	12.27	53.07	2.45	93.15	1.25	1.83
O-1	85.80	11.66	11.66	52.63	2.81	93.09	0.80	1.36
B-1	77.79	9.37	11.75	53.50	2.21	92.19	2.98	4.40
B-2	81.49	12.14	12.77	52.04	2.65	92.73	1.43	3.98
S-1	87.30	10.04	13.97	55.84	1.53	94.29	0.90	1.41
Average	80.00	11.24	12.90	53.95	3.06	90.42	1.28	2.46

*Prepared Cane + Cush-Cush

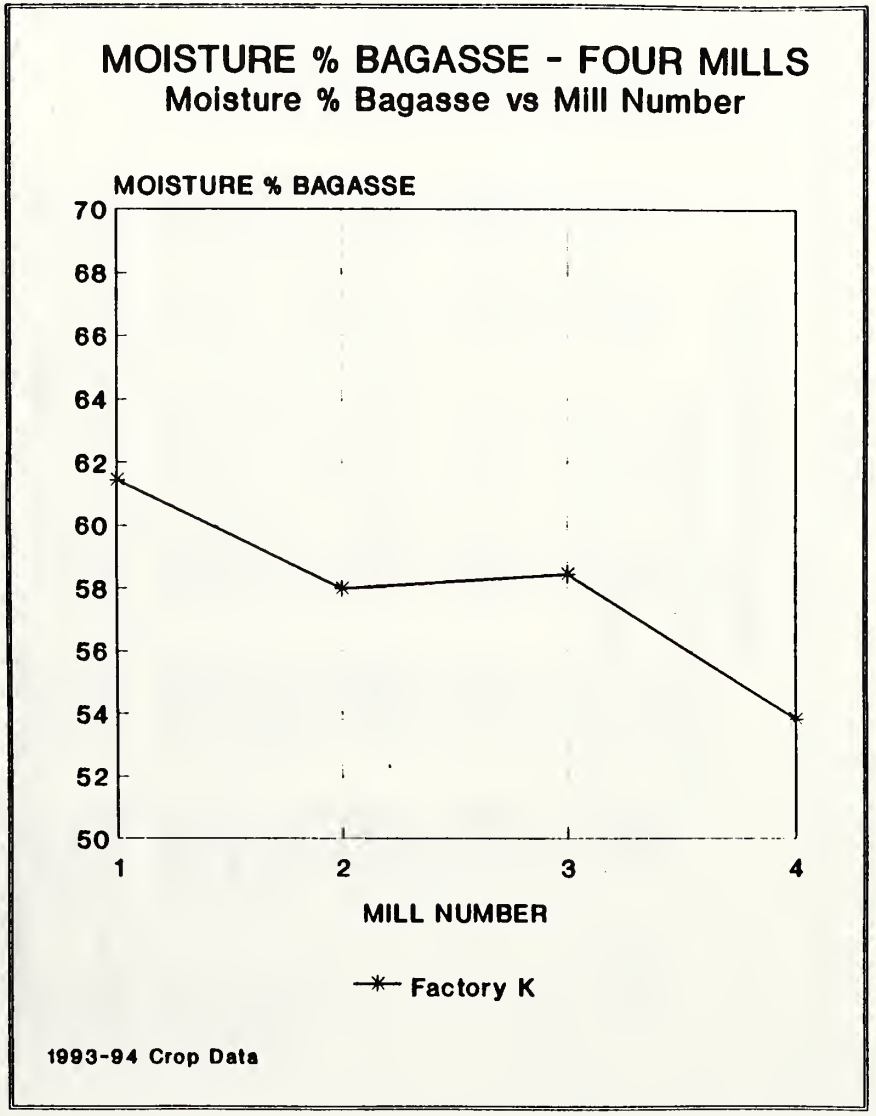
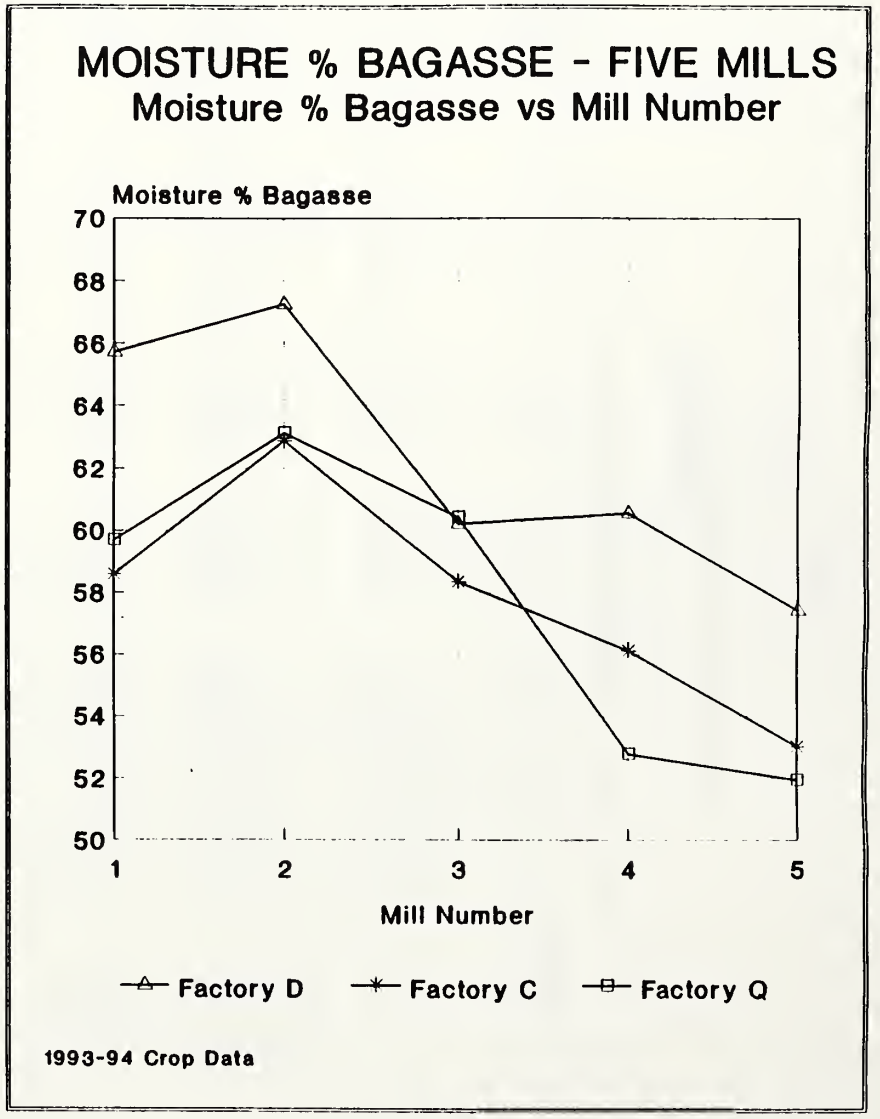


Figure 1



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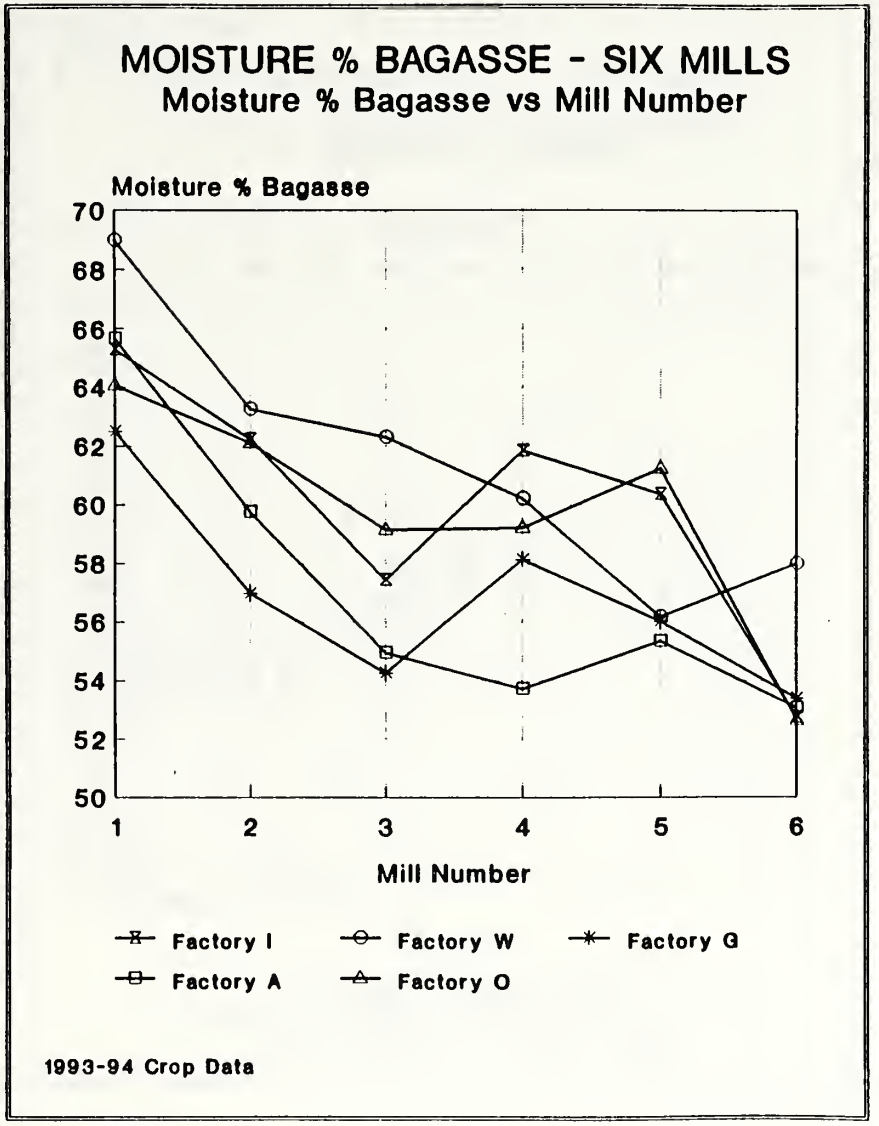

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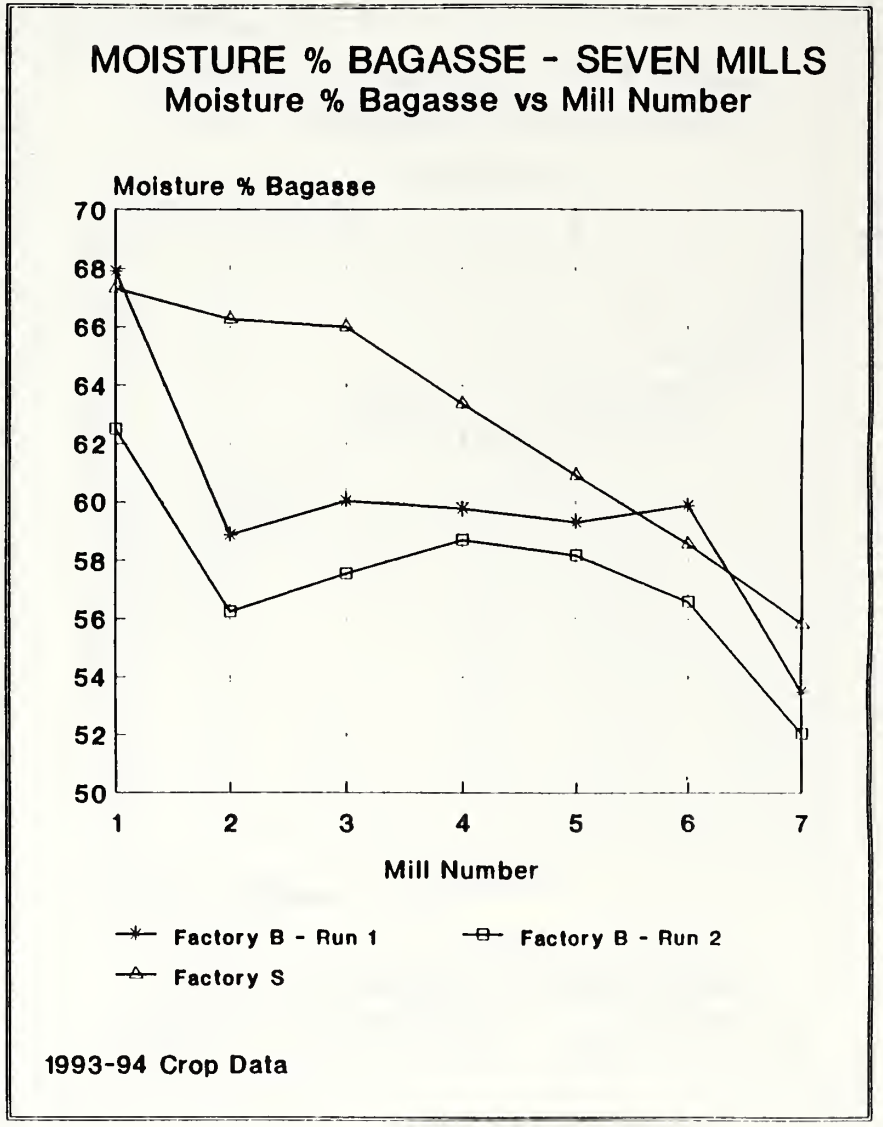

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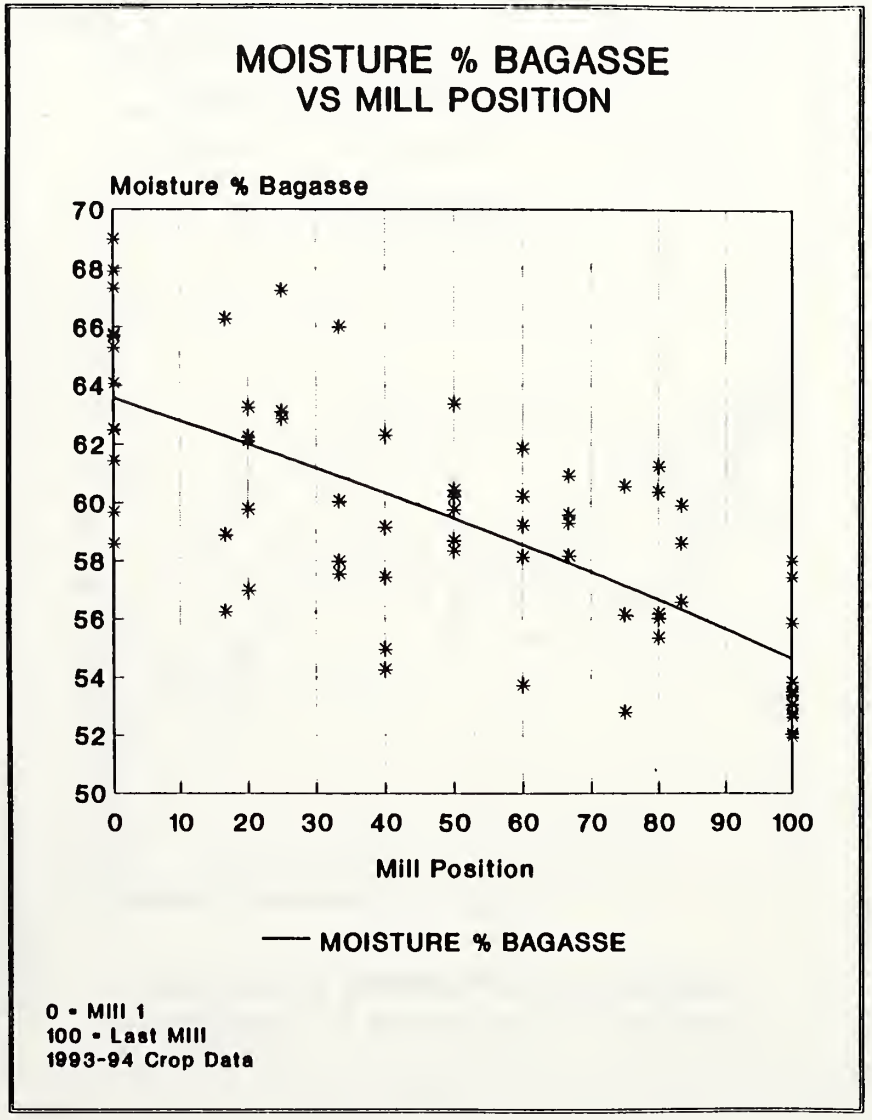

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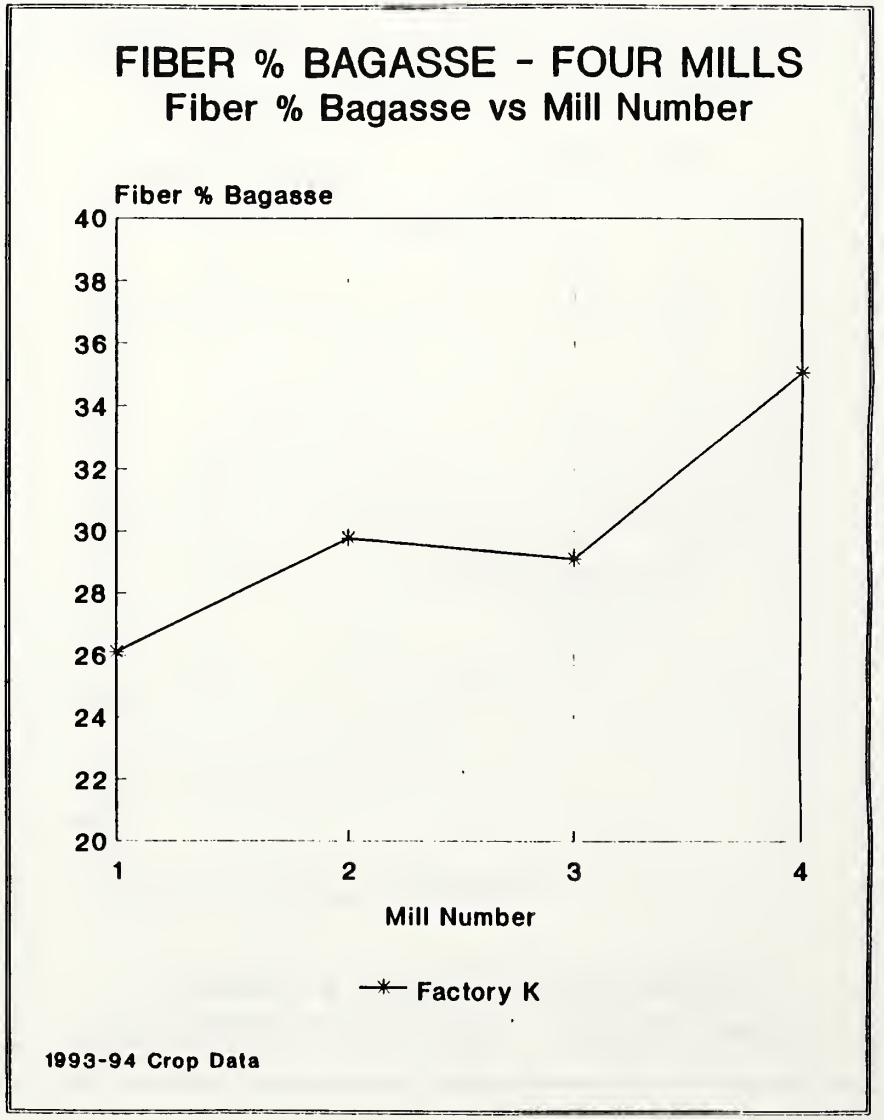

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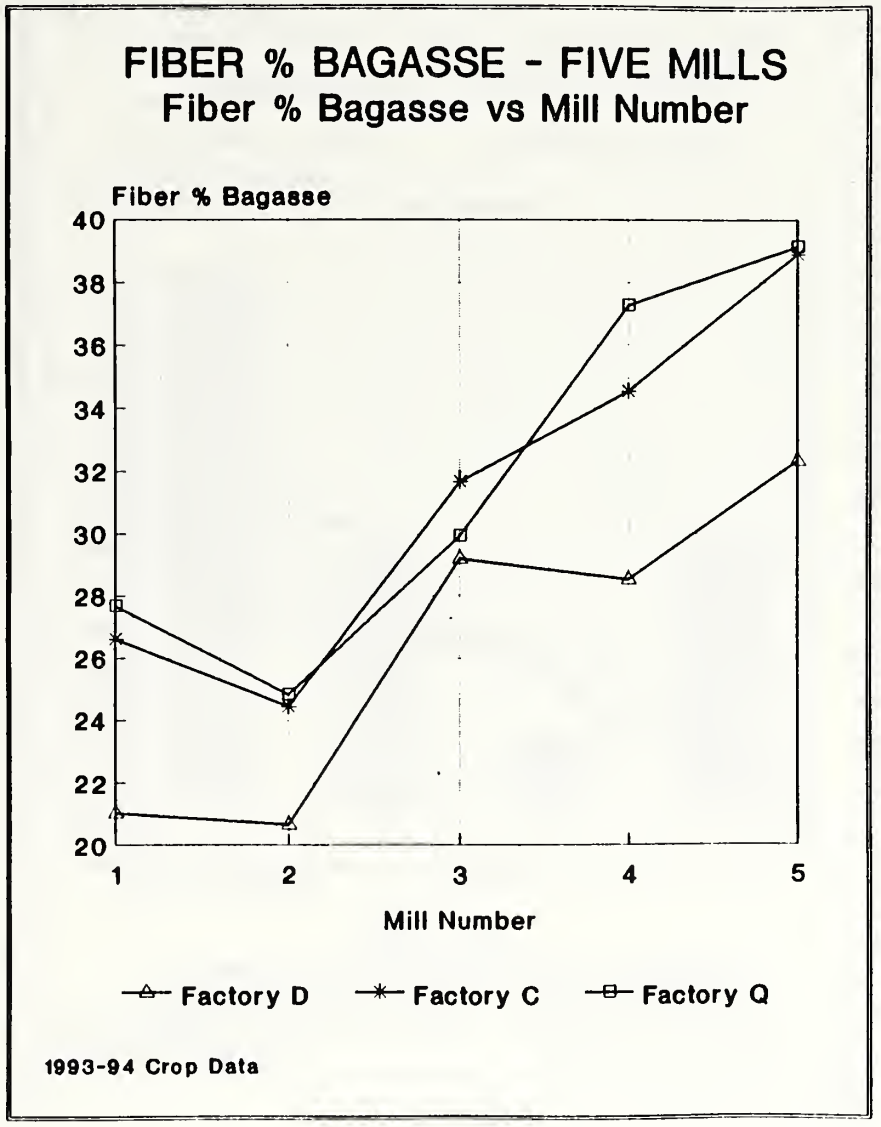

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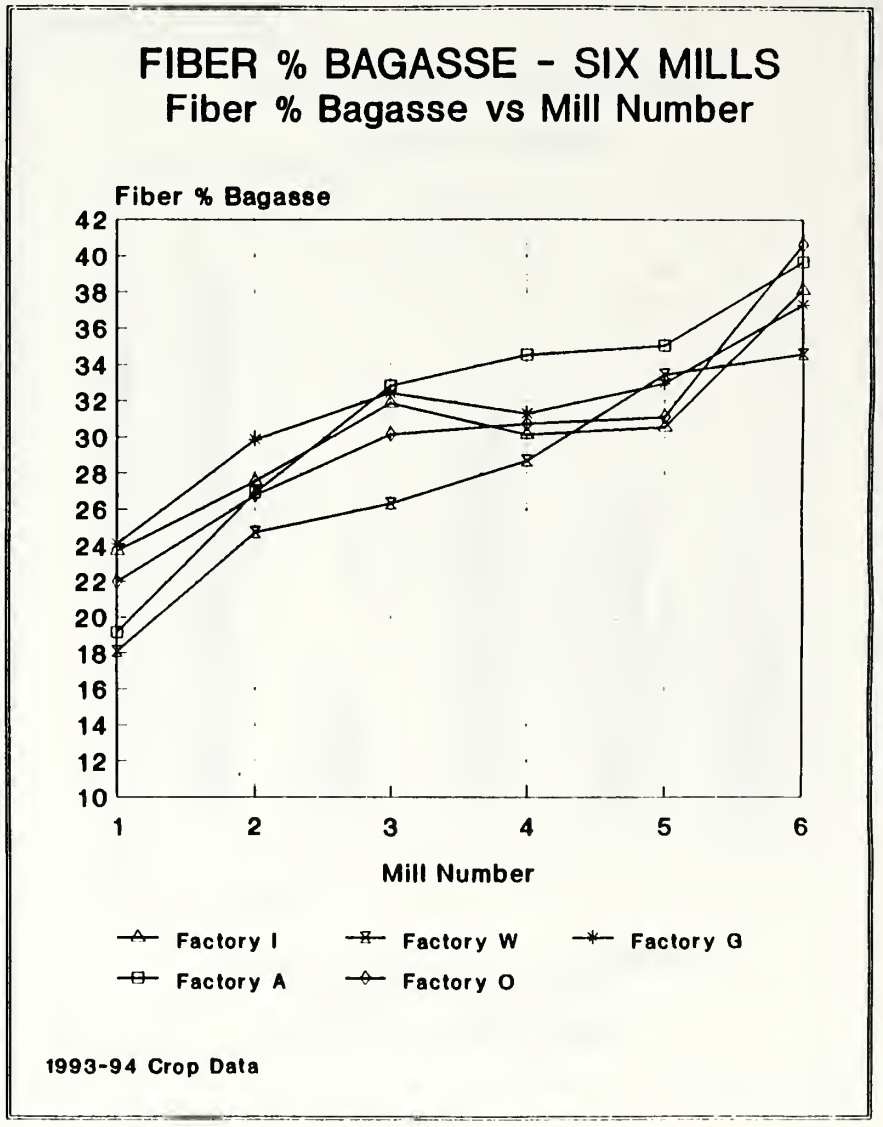

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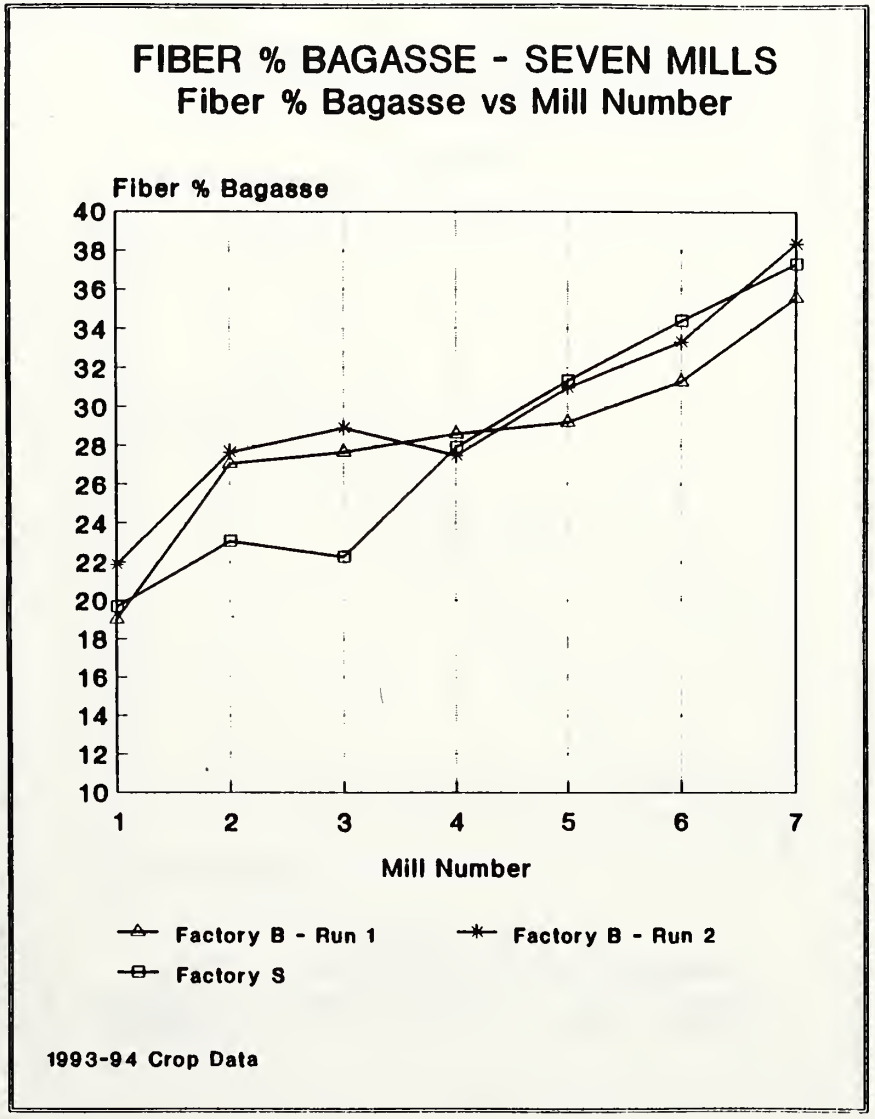

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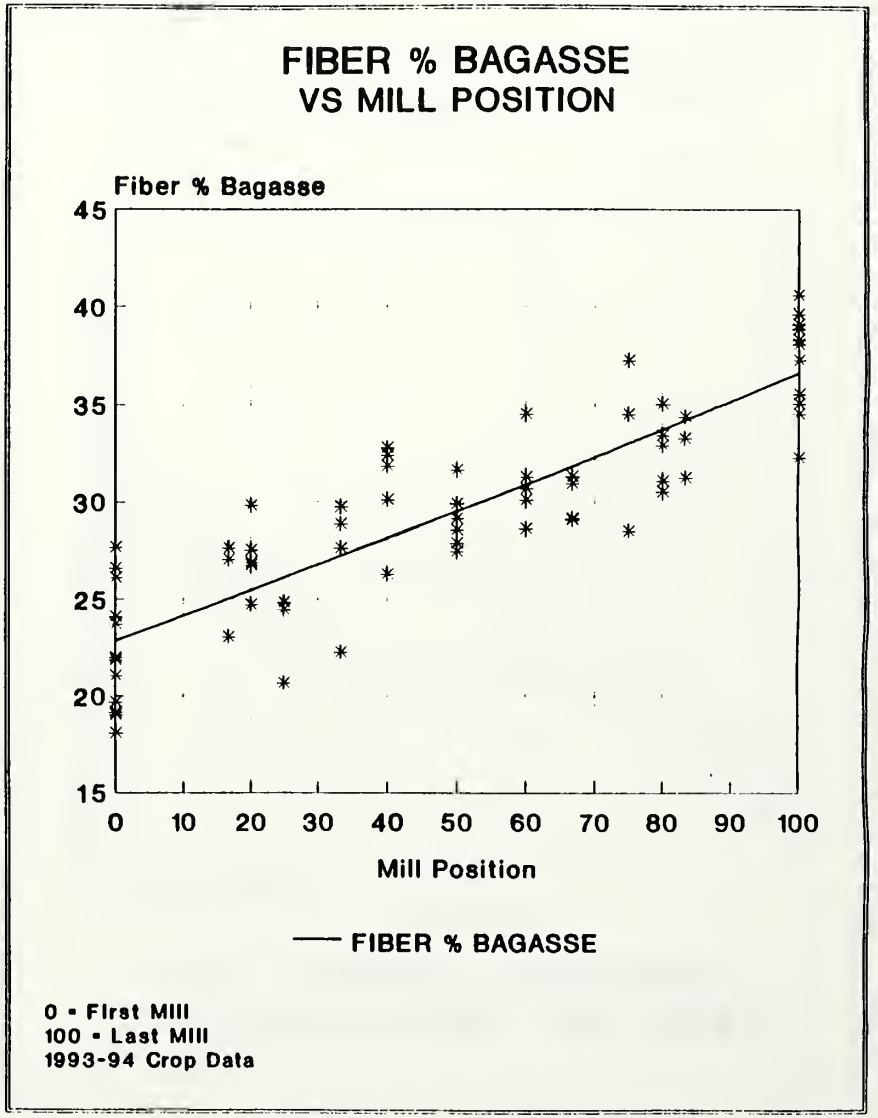

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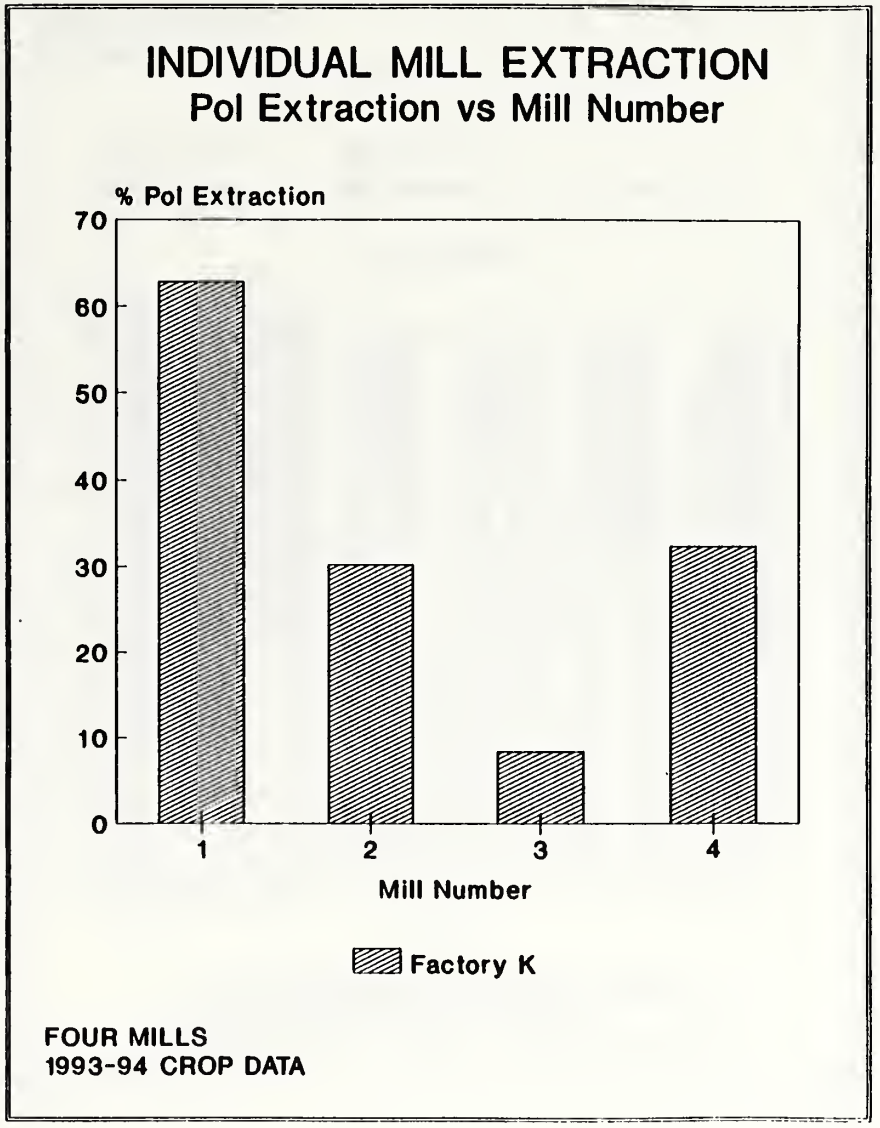

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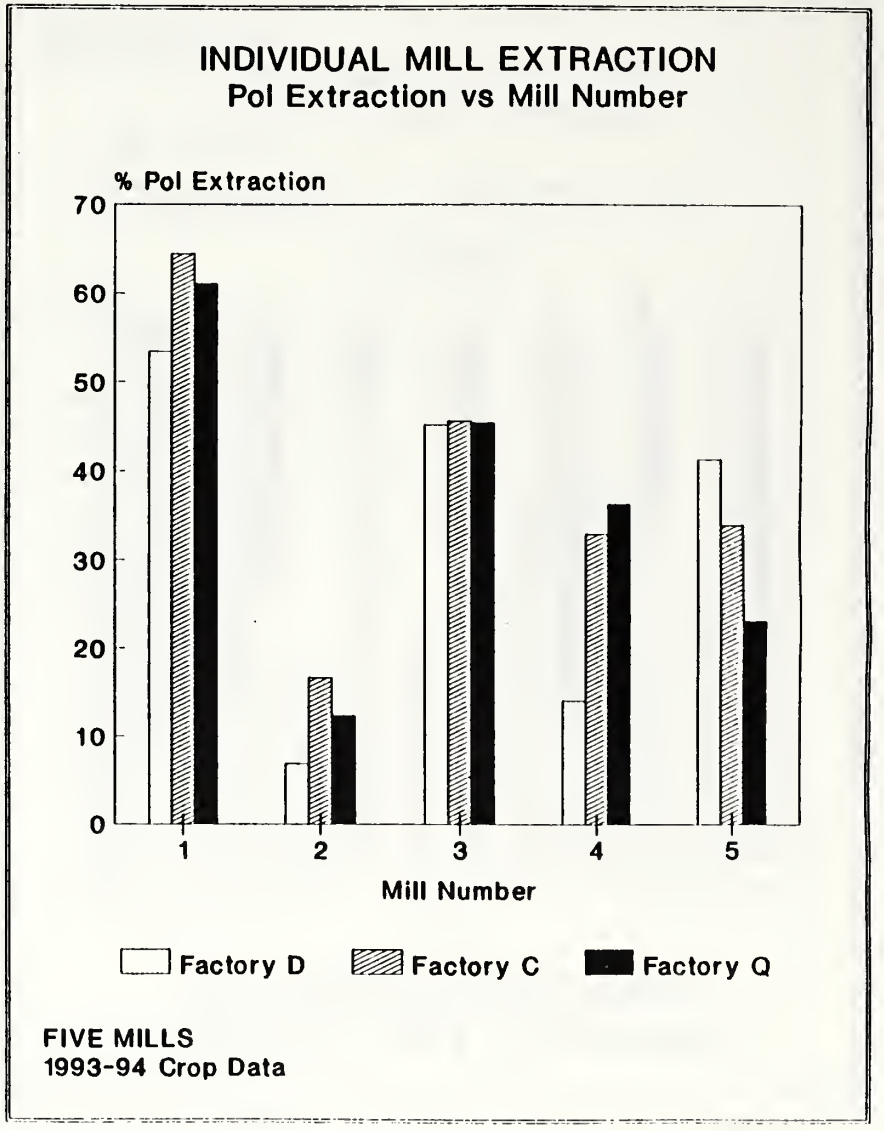

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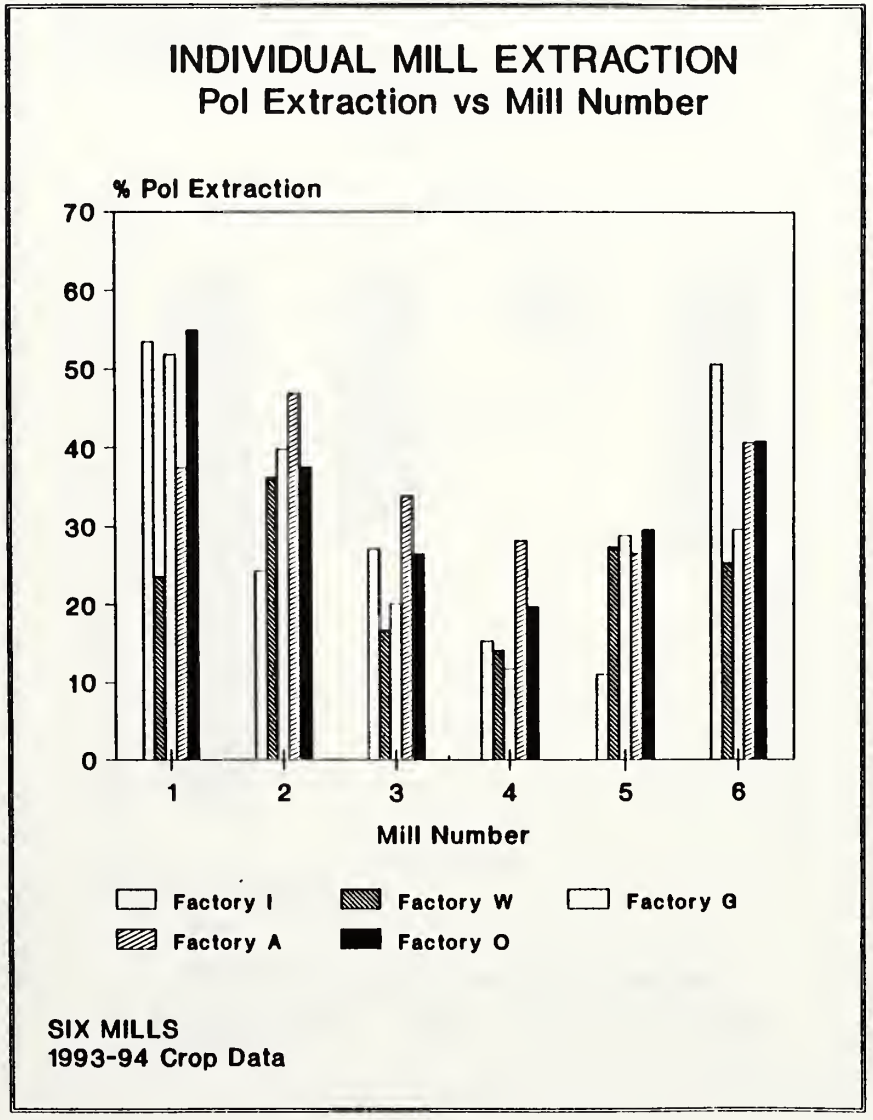

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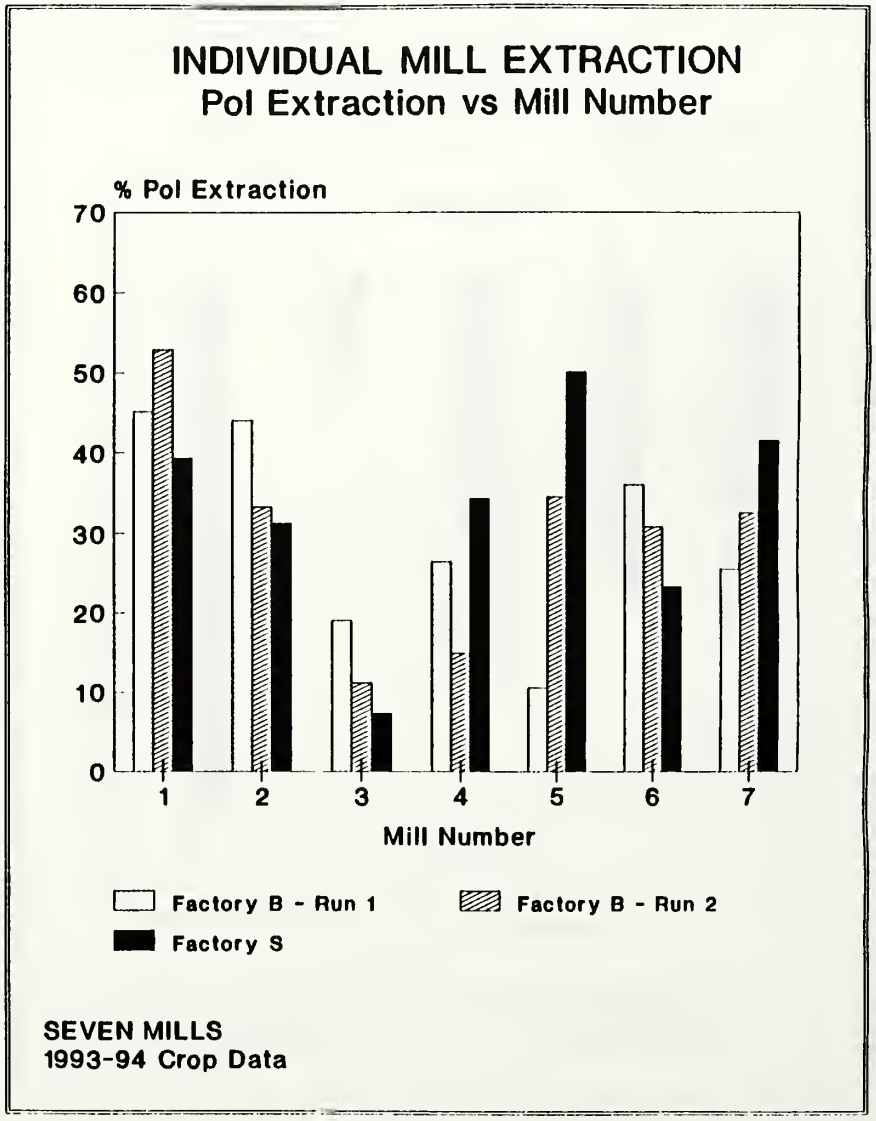

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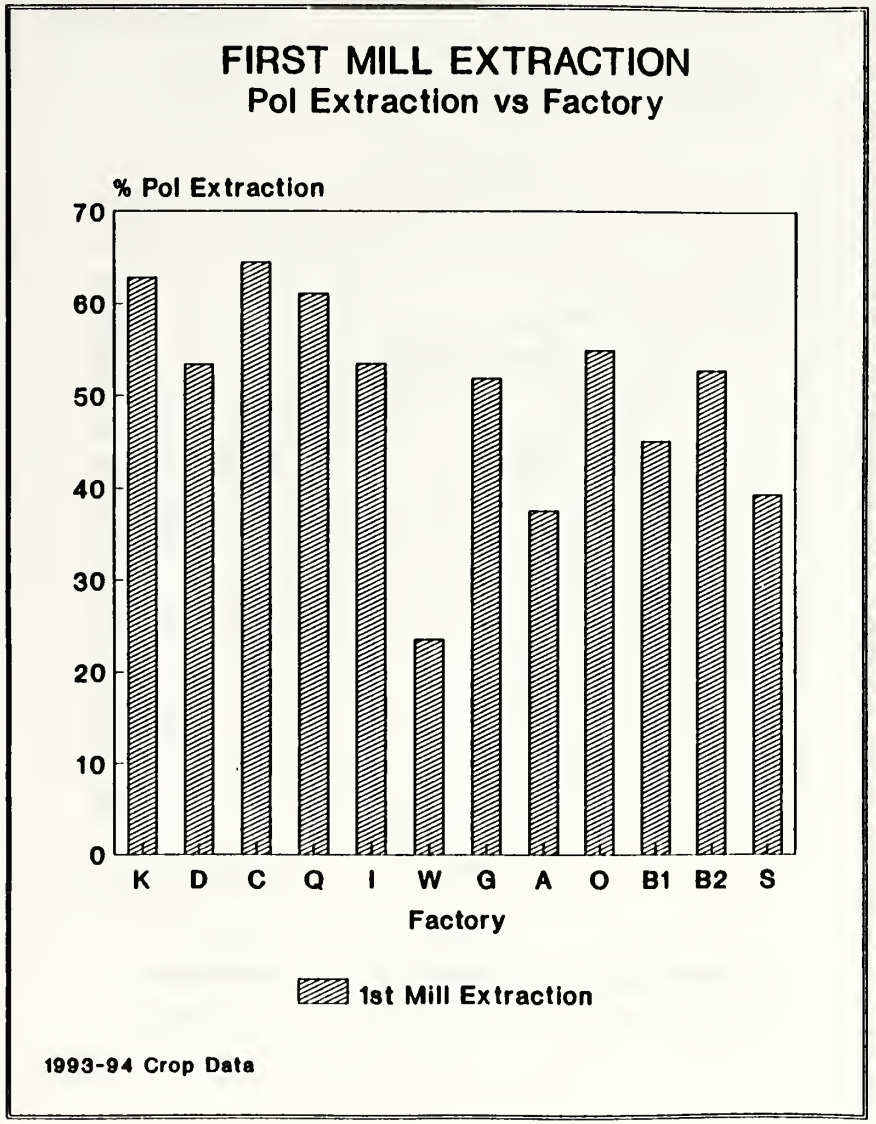

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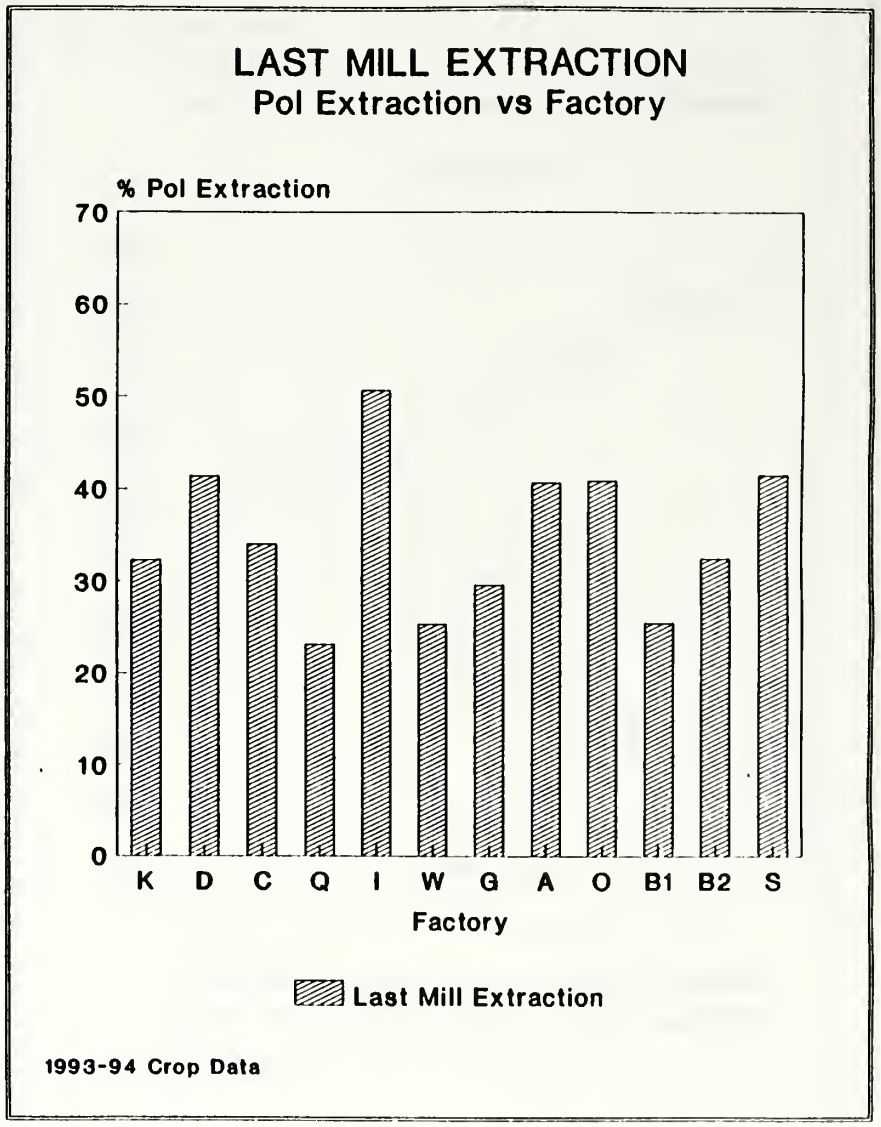

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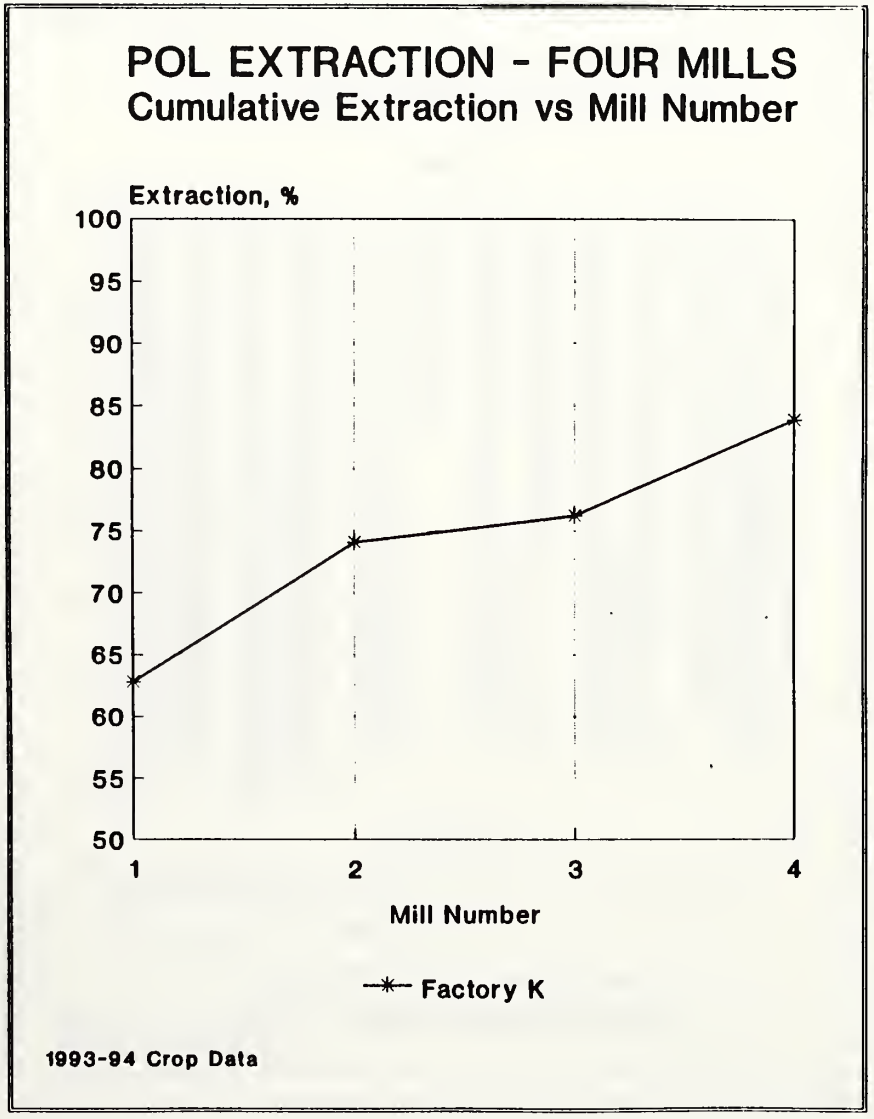

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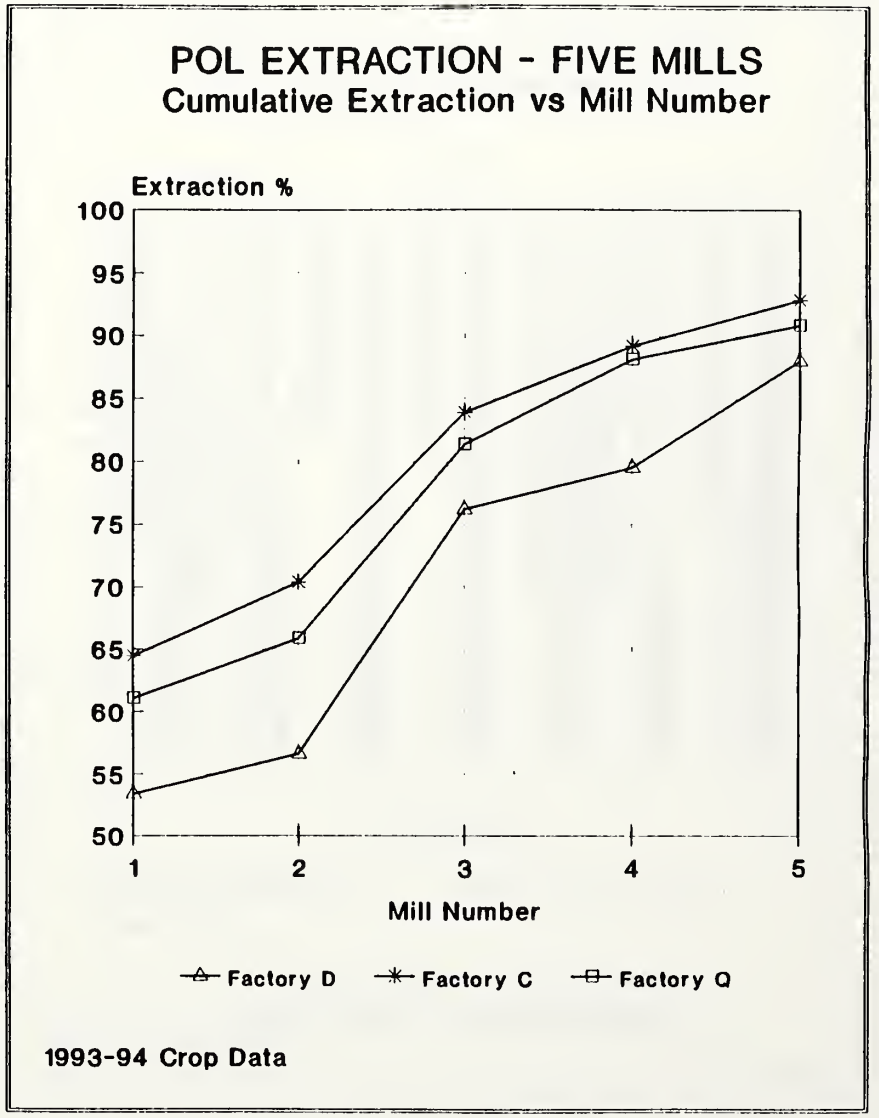

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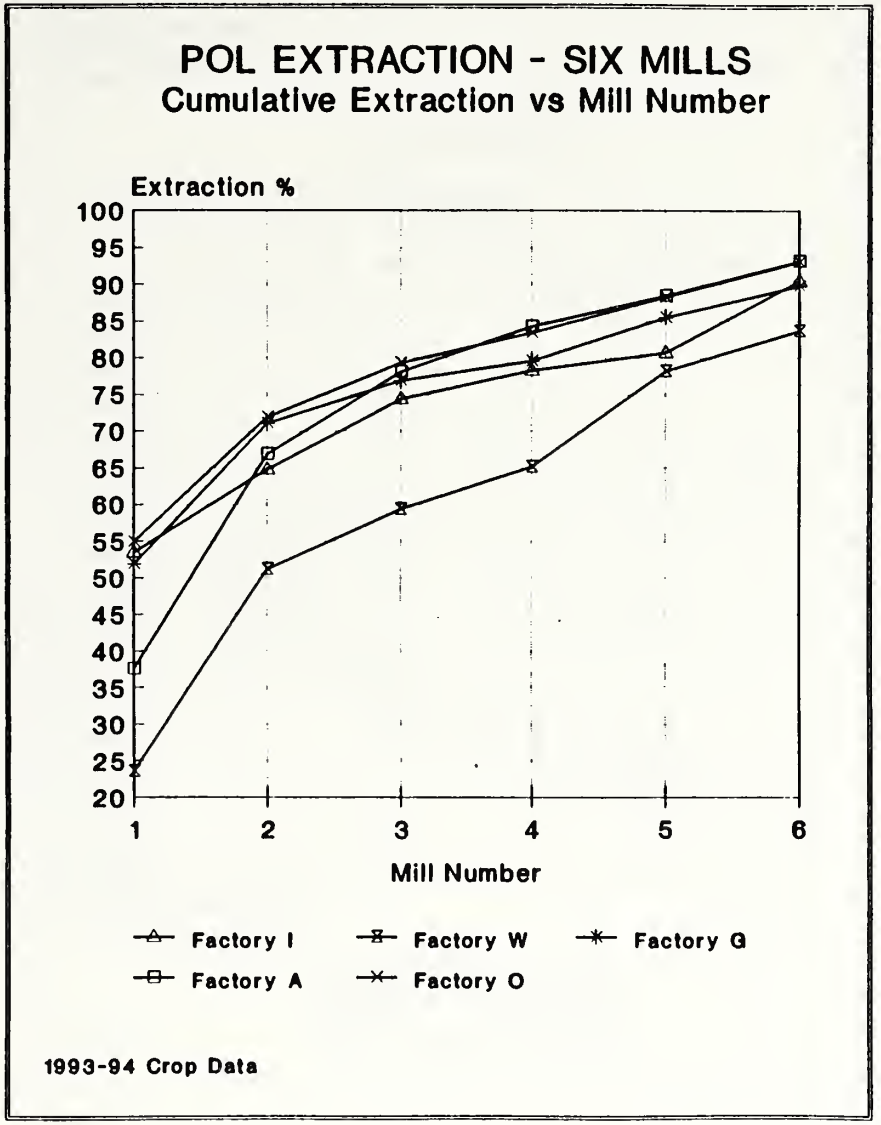

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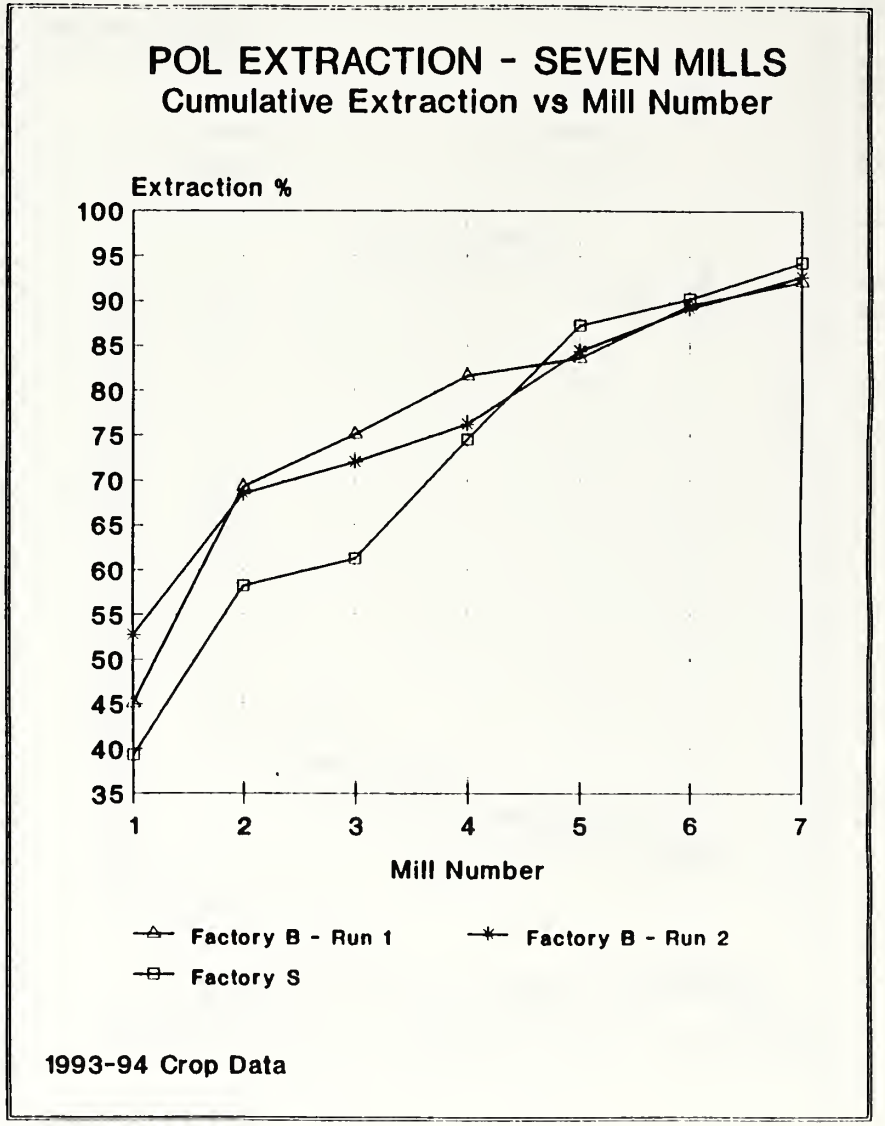

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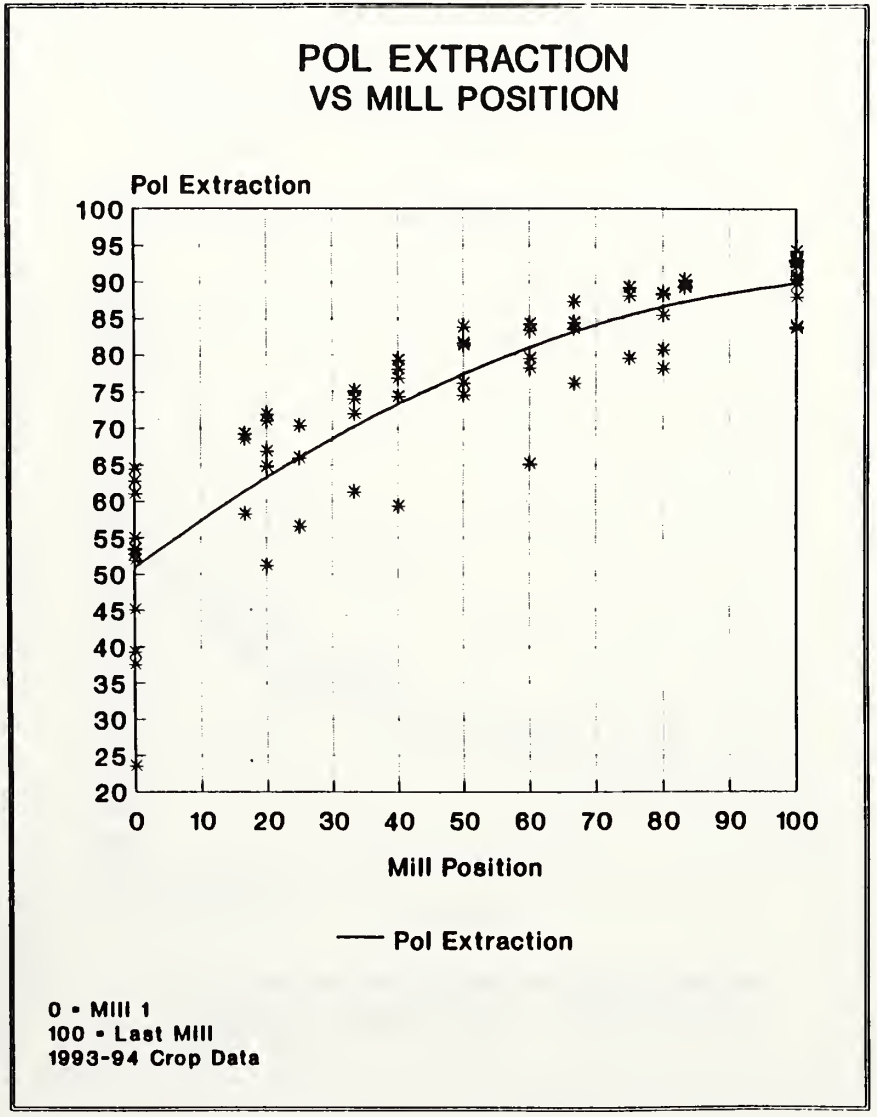

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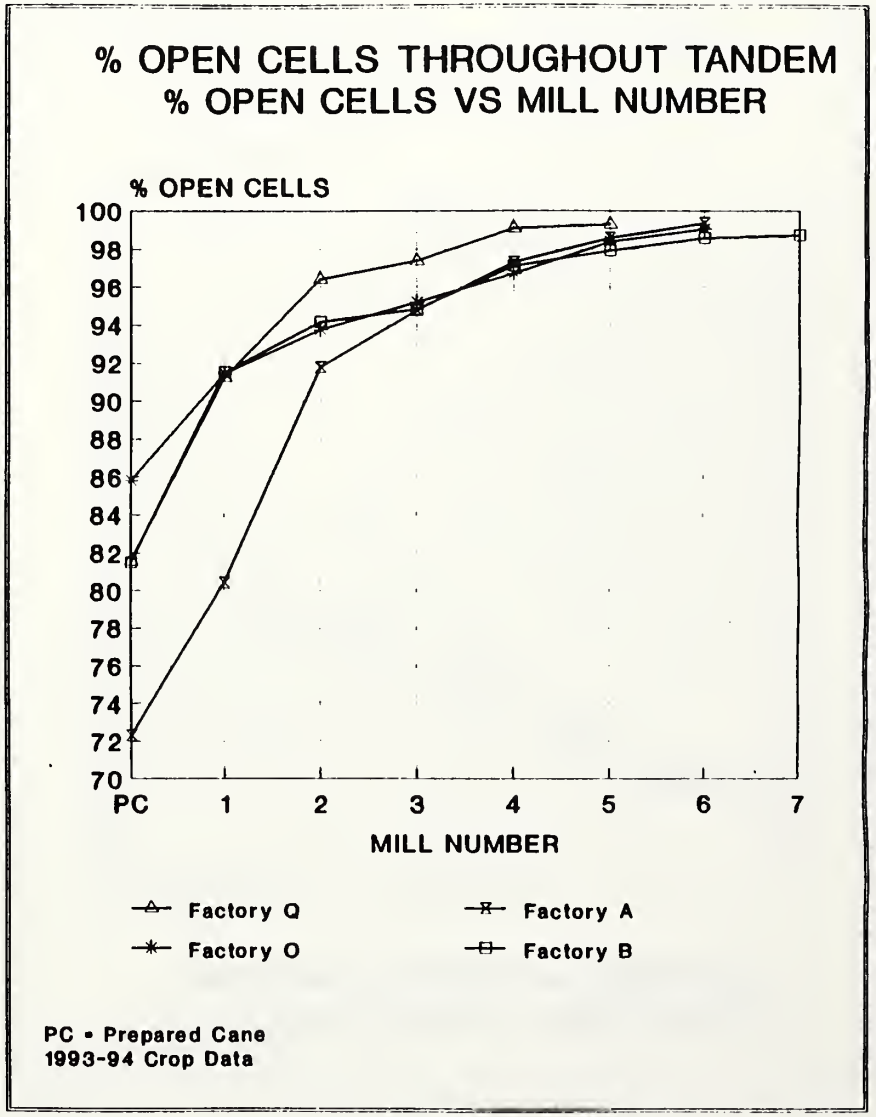


Figure 22

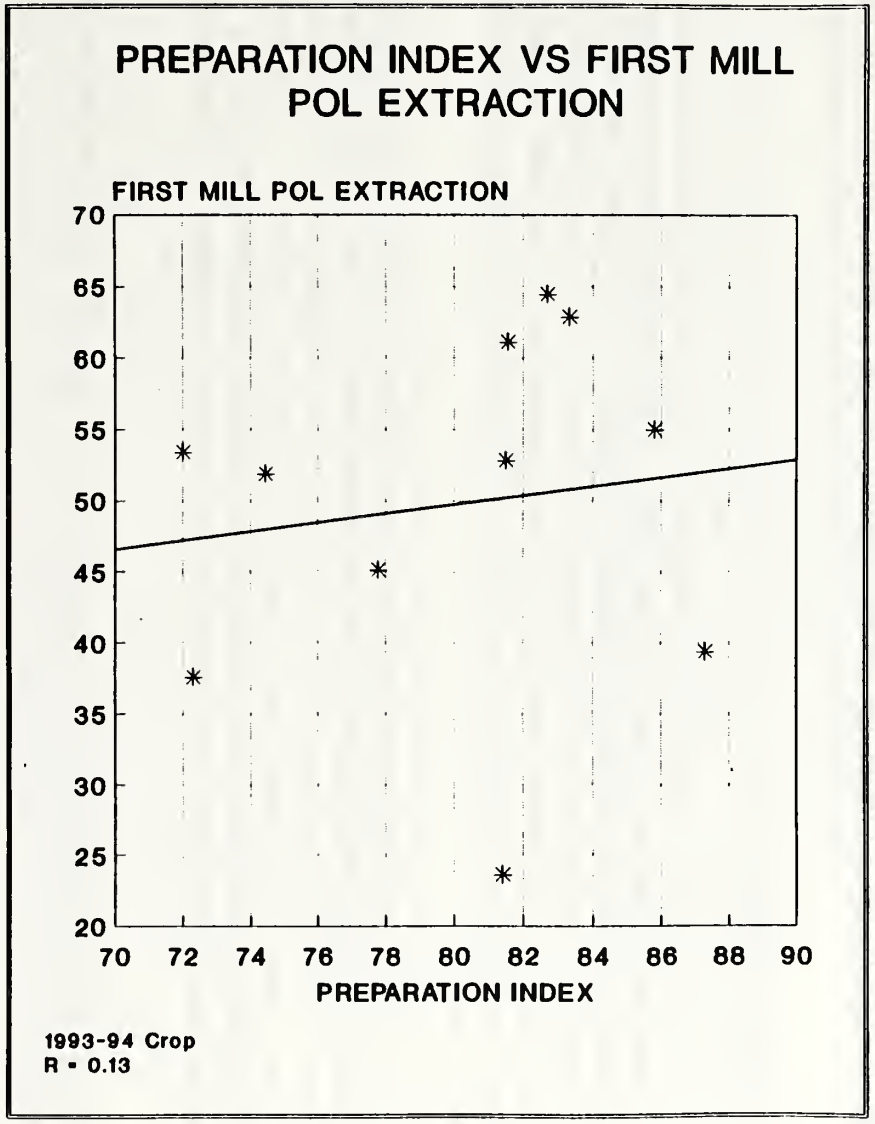

PREPARATION INDEX VS FIRST MILL POL EXTRACTION
FIRST MILL POL EXTRACTION
70
65
60
55
50
45
40
35
30
25
20
70 72 74 76 78 80 82 84 86 88 90
PREPARATION INDEX
1993-94 Crop
R = 0.13

Figure 23

PROCESSING RESEARCH, PURIFICATION SYSTEMS AND ANALYTICAL PROCEDURES

Stephen J. Clarke, Monica Fontenot, Jian-Mei Yu, Wallace Millet, and Yujian Xu
Audubon Sugar Institute

Introduction:

Several research projects related to raw sugar production have continued from the previous year, and new projects have commenced, especially in the area of purification systems applicable to cane sugar refining operations. Emphasis has been placed upon development of the analytical methods and equipment necessary for evaluation of process operations, both in regular factory operations and in research projects.

Studies directly related to factory operations included the impact of harvesting systems on cane quality and analysis (a new study), clarification and filtration systems, evaporator scaling and the treatment of cane wash water.

The purification systems under study at ASI and mills include modifications to conventional systems and radically different approaches. The latter may well be beneficial or even essential if membrane micro- and nano-filtration and chromatographic systems are to be applied in cane sugar operations.

Cane Quality Measurements:

Environmental considerations and cane quality factors are putting pressure on the sugar cane industry to modify the harvesting system. The desired goals are avoidance of cane burning, and delivery of clean, fresh cane. The latter would eliminate the need to wash cane. Success at this venture will facilitate uniform evaluation of potential modifications to the harvesting system including harvesters. The scope of this work is intended to develop standard means for evaluation of the cane quality and the impact of changing cane quality on factory operations.

Extended sampling was performed at Savoie Industries with three levels of potential variation (1) three varieties of cane, (2) burned and unburned, (3) loaded with a conventional loader or a CAMECO continuous loader. All cane in this study was cut with a two row harvester. Some of the samples were cut and loaded under wet conditions. All the samples were analyzed by the standard core/press system. Differences were observed but their significance is questionable. The exercise was very useful in developing the sampling and

Research support has continued to be received from the American Sugar Cane League and funding by the Domino Sugar Corporation began this year.

analytical techniques and the data handling system best suited to the task. Samples of all cane and press cakes were saved for direct ash analysis for comparison with the ash content inferred from the core press analysis.

The Lula mill was run twice for periods of about two hours on unwashed and unburned cane which had been cut with the two row harvester and loaded with the continuous loader. No significant problems were encountered but there were increases in the suspended solids in mixed and crusher juice, ash in bagasse and in the quantities of filter cake produced. In these tests, no adverse affects were observed in the quality of the clarified juice. The length of the test was too short to evaluate any effects later in process.

Clarification And Filtration:

Turbidity measurements on clarified juice in several sugar factories showed considerable variation, confirming the results of previous years. Laboratory clarification tends to produce clearer juice than obtained from the factory clarifiers, probably due to the prolonged contact time with the juice and the recirculation of the filtrate.

The background turbidity of clarified juice from several mills was measured before and after filtration through membranes and filters of decreasing pore size. Significant reduction in turbidity was achieved only with pore sizes below one micron. Particles this small are difficult to remove by conventional filtration and illustrate the need for improved flocculation systems and/or microfiltration systems. The chemical nature, including zeta-potential and other pysico-chemical characteristics, are under study.

A problem with the filtration properties of some raw sugar from a mill in 1993 was studied and attributed in part to poor pH control in clarification. This lead to precipitation of calcium aconitate in the vacuum pans. Very large amounts of acid soluble precipitate was observed in A- and especially B-molasses. This was associated with periods of high pH in the clarifiers due to over liming. Increased quantities of evaporator scale with an unusual appearance was noted and the composition of this scale is under investigation. A study of the analysis of whole and affined raw sugar using X-ray fluorescence was begun and the problem sugars could be easily identified.

The study of an ion-exchange softening system for clarified juice has been completed (M.S. Thesis, Ms. Youjian Xu, 1993). The system involves the regeneration of a carboxylic acid resin with phosphoric acid and recirculation of the spent regenerant to the mixed juice tank to improve the initial clarification, both in terms of clarity and calcium levels.

A floatation clarification system for limed unheated juice was applied successfully at a mill where the solids (bagacillo) content of the juice had been considerably reduced by the use of DSM screens. The intent of this system is to remove field soil and other particulates before heating the juice. The turbidity of the juice from this pilot clarifier was slightly higher than for regular clarified juice but it should be noted that this juice would have to go through a second clarification stage, preferably involving complete filtration of the juice. Also, the juice used in the mill contained the recycled filtrate which would not be the case in

actual practice with a floatation system. The retention time in the floatation clarifier was approximately four minutes but the problem of microbial degradation in such a system remains, especially for the mud which has to be desugared. Very high mud solids contents (10-12%) were achieved for the aerated and drained scums, suggesting that dilution and filtration should lead to low physical losses of sugar.

Two filtration systems were under study. The first, a membrane press filter, most suitable for clarifier mud desugarization, gave good results with low sugar content in the cake. Calculations based on this data indicate that as much as 60% of the sugar lost in conventional rotary vacuum filtration could be recovered with a membrane press filter. The major problem with this system is the pumping of the mud to filter without breaking up the floc and reducing the filter performance.

A small thickening filter, a potential replacement for a clarifier, was tested on regular clarifier feed using several filter cloths. Excellent juice clarity was achieved in some cases but the major problem was the same as before - the maintenance of good floc under pressure. Approaches to in-line flocculation under pressure are being investigated.

The preliminary study of a clarification system for cane wash water and other waste streams from the mill has been completed and the operating conditions and performance characteristics determined. Typical operating conditions would be -

> optimum pH after liming of water: 8.3-8.7; (The quantity of lime varied depended upon the history of the water but was usually in the range of 0.4 to 0.7 lb per ton of cane through the system. If the water was recirculated immediately to the cane tables, the lime requirement would be reduced since the anaerobic conditions developed in the ponds would not occur.)
>
> optimum flocculant dosage: 1.5-2.0 ppm on water;
>
> retention time: approximately three minutes;
>
> gross suspended solids content of "clean" water:
> less than 0.1% and usually zero;
>
> solids content of mud (underflow): 12-15% by wt.

If this system is used for wash water treatment, the underflow would be pressure filtered or pumped directly to a holding pond.

DEXTRAN SURVEY 1993

Durriya Sarkar

Audubon Sugar Institute

The 1993 dextran survey is for Louisiana Sugar Mills reporting daily dextran data on sugar analyzed by the Haze method. Dextran data on juice samples (core, crusher and dilute) done by the ASI II method were also received from Iberia Sugar Cooperative. The sugar dextran showed a pattern similar to that of the core juice dextran. Crusher and dilute juice dextran also recorded higher values for dextran when the core juice did.

Figure 1. Shows the daily average dextran in sugar for the mills. The three periods marked show the times when the dextran was above penalty level (250 MAU). The high levels of dextran during days 4 and 5 were the result of a mill breakdown. For the other two periods as we have noticed in the past seven years the dextran level goes up after it rains and the low temperature is 50°F or higher.

Figure 2. The daily average rainfall in inches for the season with two periods marked when dextran was above penalty level. Although there was some rainfall at other times dextran was not a problem as temperatures were low.

Figure 3. Average high and low temperatures recorded for the season show a lot of fluctuations.

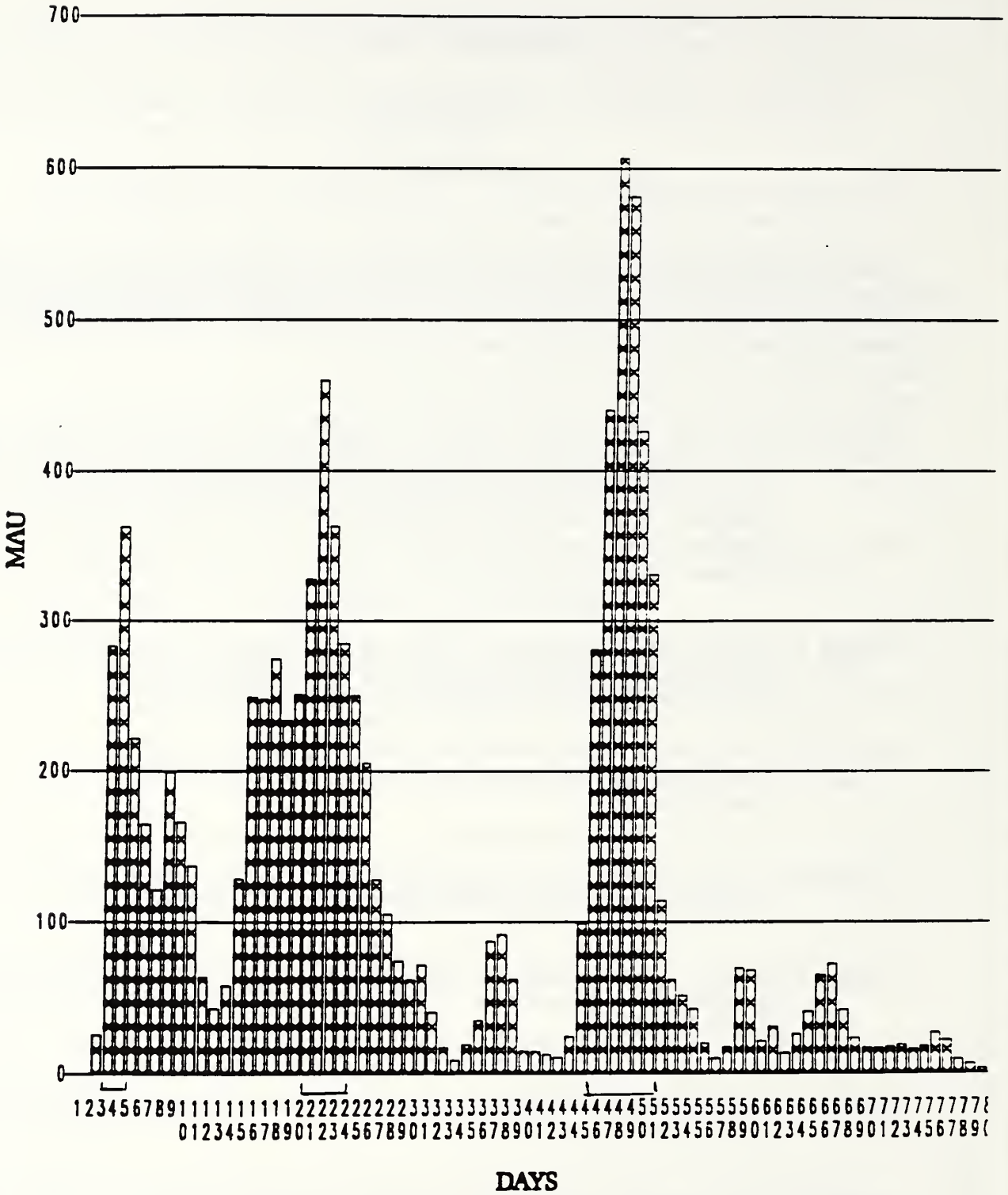
Figure 4. Average dextran in sugar for the mills in the Teche region, shows a graph with the two periods of high dextran similar to the average in Figure 1.

Figure 5. Average dextran in sugar for the mills in the Bayou Lafourche area. This also shows the two periods of high dextran with an extended first period between day 15 and day 26.

Figure 6. Average dextran in sugar for the mills in the Mississipi area with three periods of penalty level dextran.

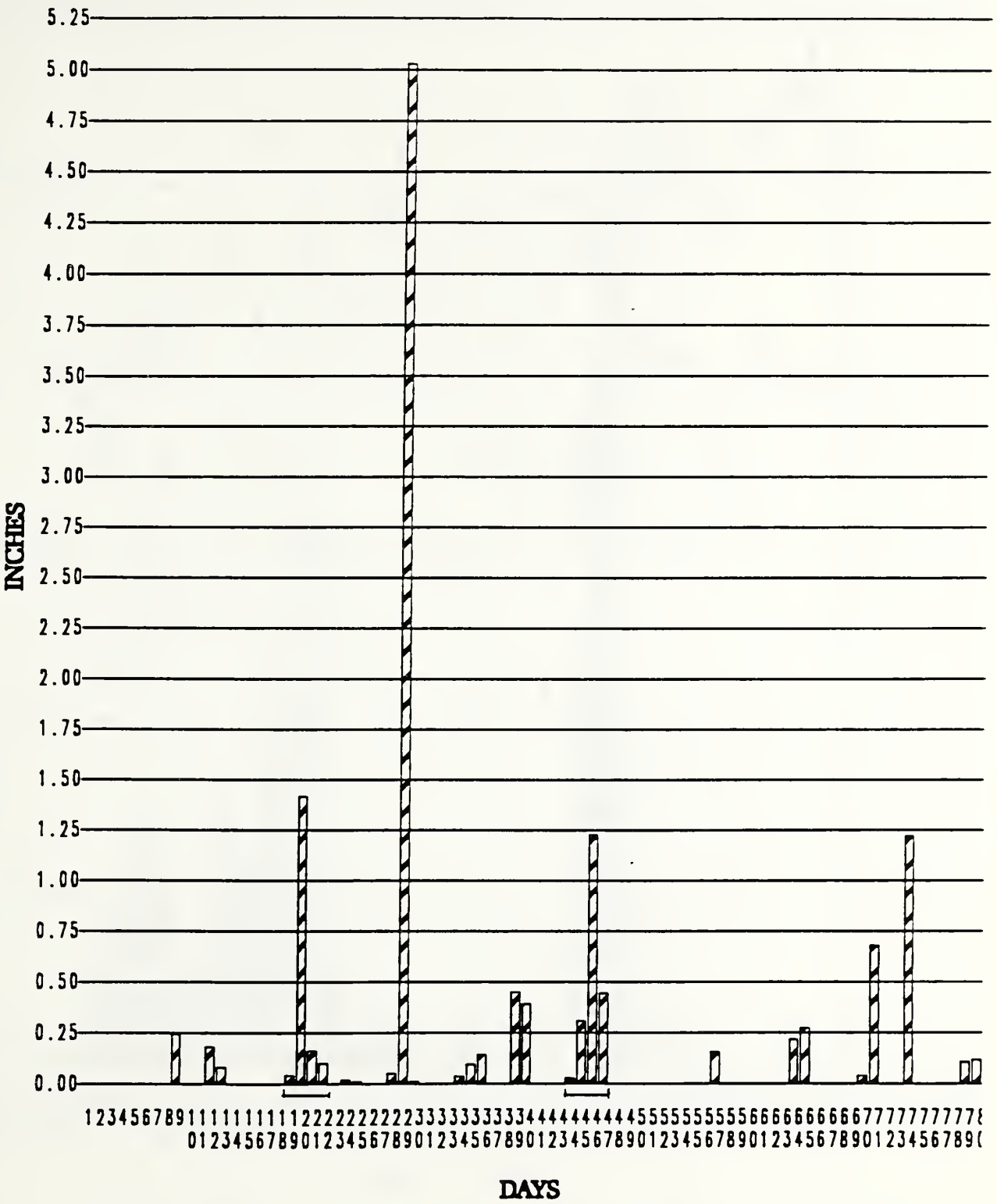
Figure 7. A bar graph showing the number of days above penalty level for sugar dextran for the 1993 season for each of the mills participating in the survey.

This project was partially funded by the American Sugar Cane League.



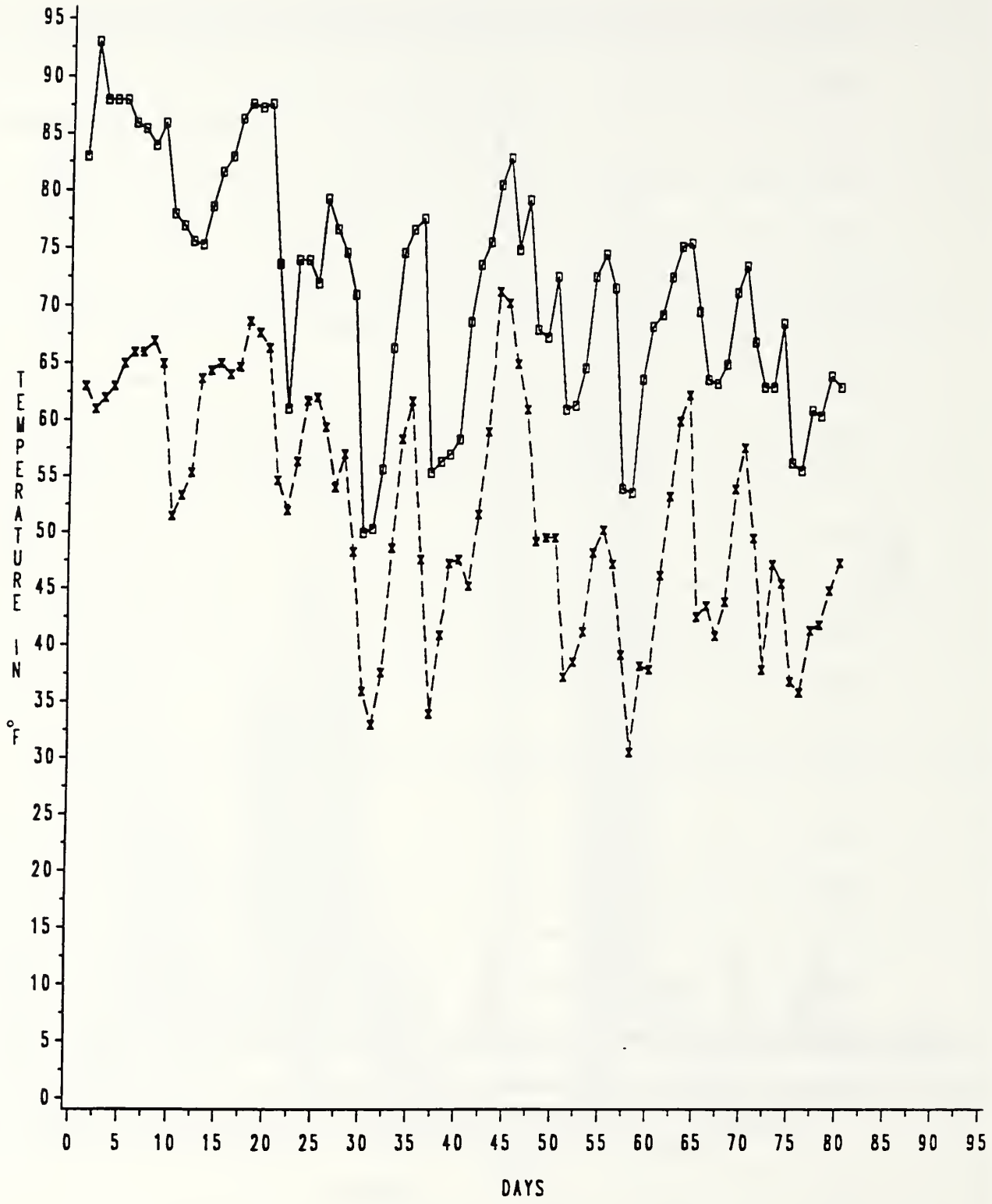
DAY 1 CORRESPONDS TO OCTOBER 1, 1993

FIGURE 1: AVERAGE SUGAR DEXTRAN FOR 1993 SEASON



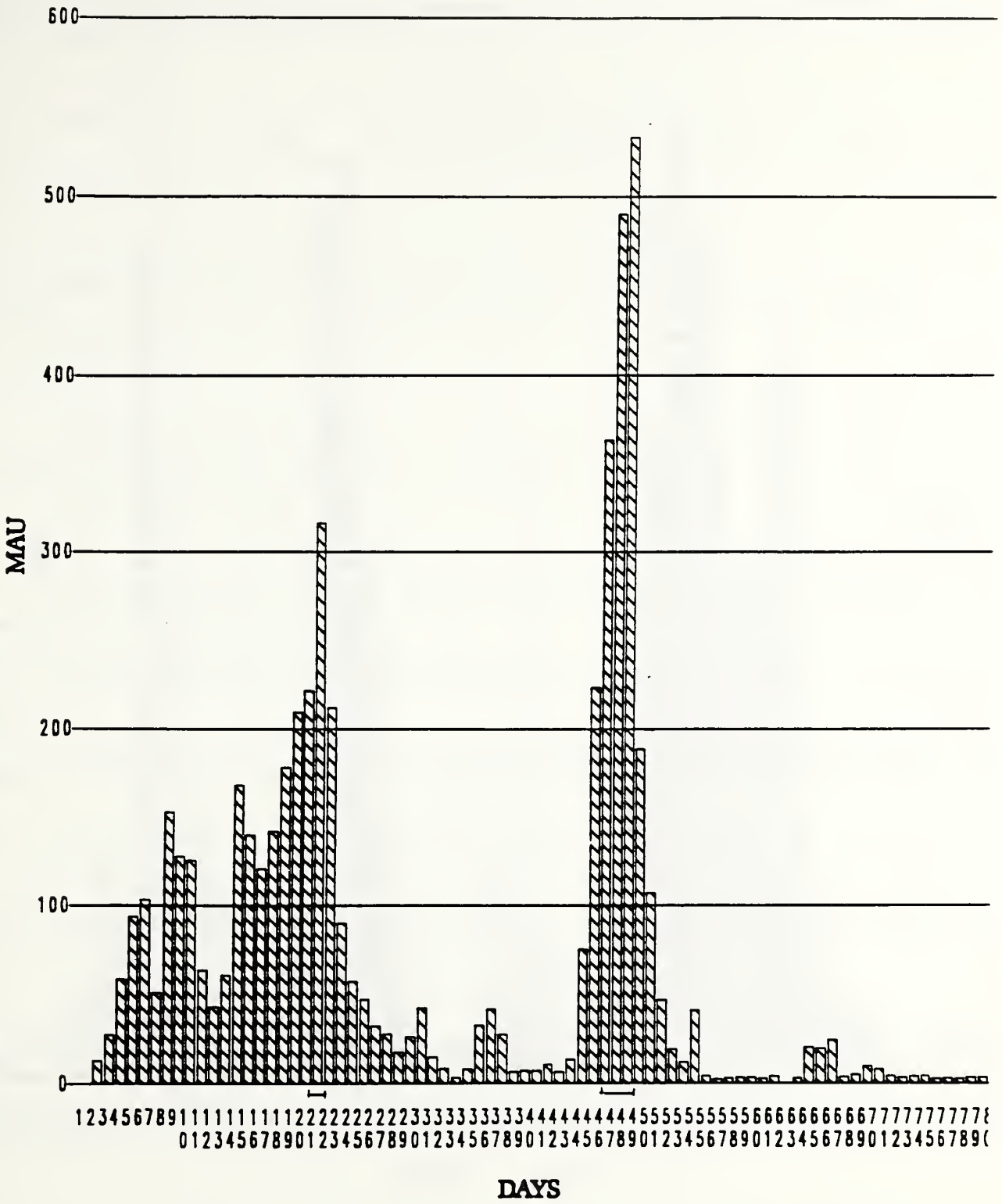
DAY 1 CORRESPONDS TO OCTOBER 1, 1993

FIGURE 2: AVERAGE RAINFALL FOR 1993 SEASON



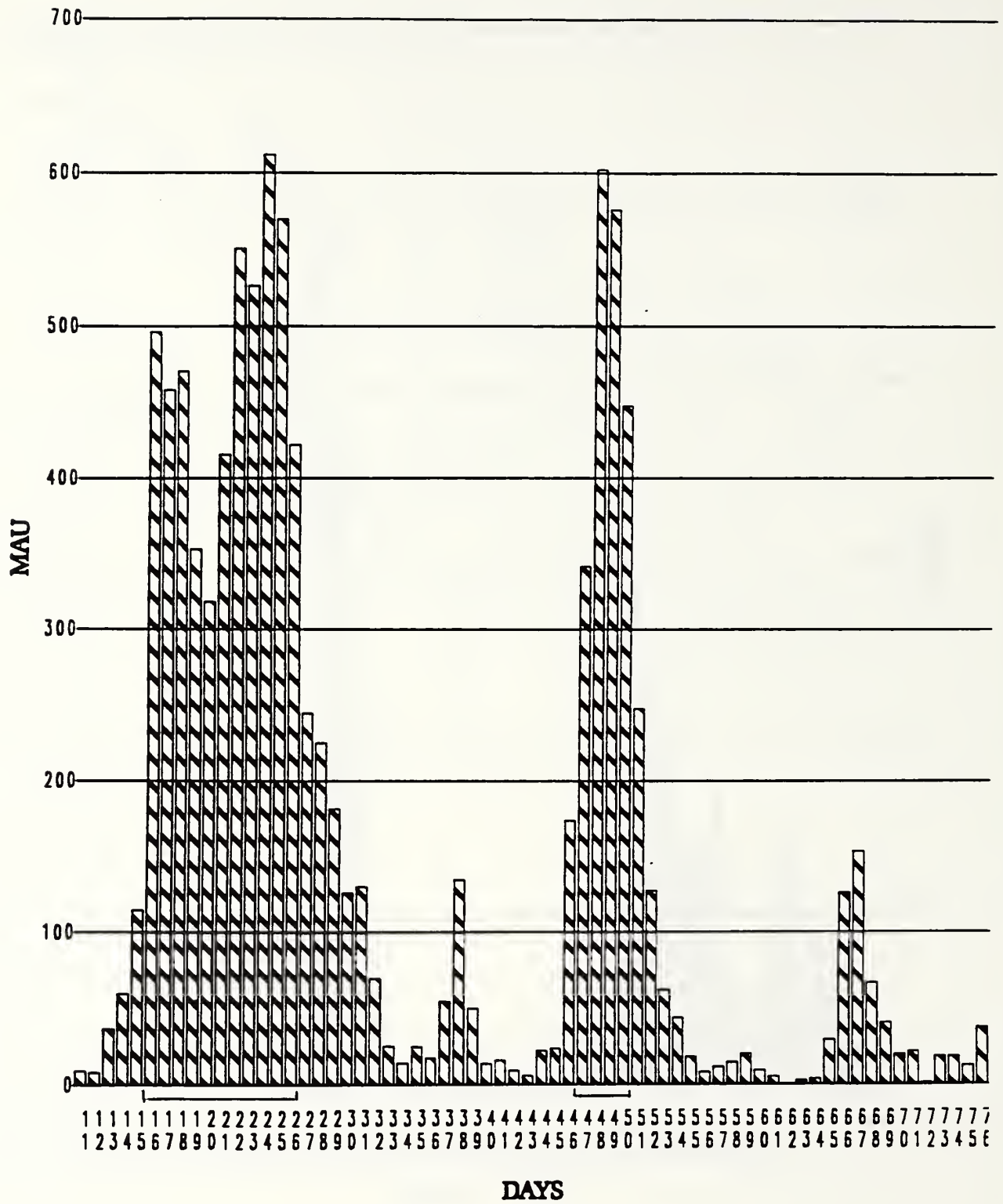
DAY 1 CORRESPONDS TO OCTOBER 1, 1993

FIGURE 3: AVERAGE HIGH AND LOW TEMPERATURE FOR 1993



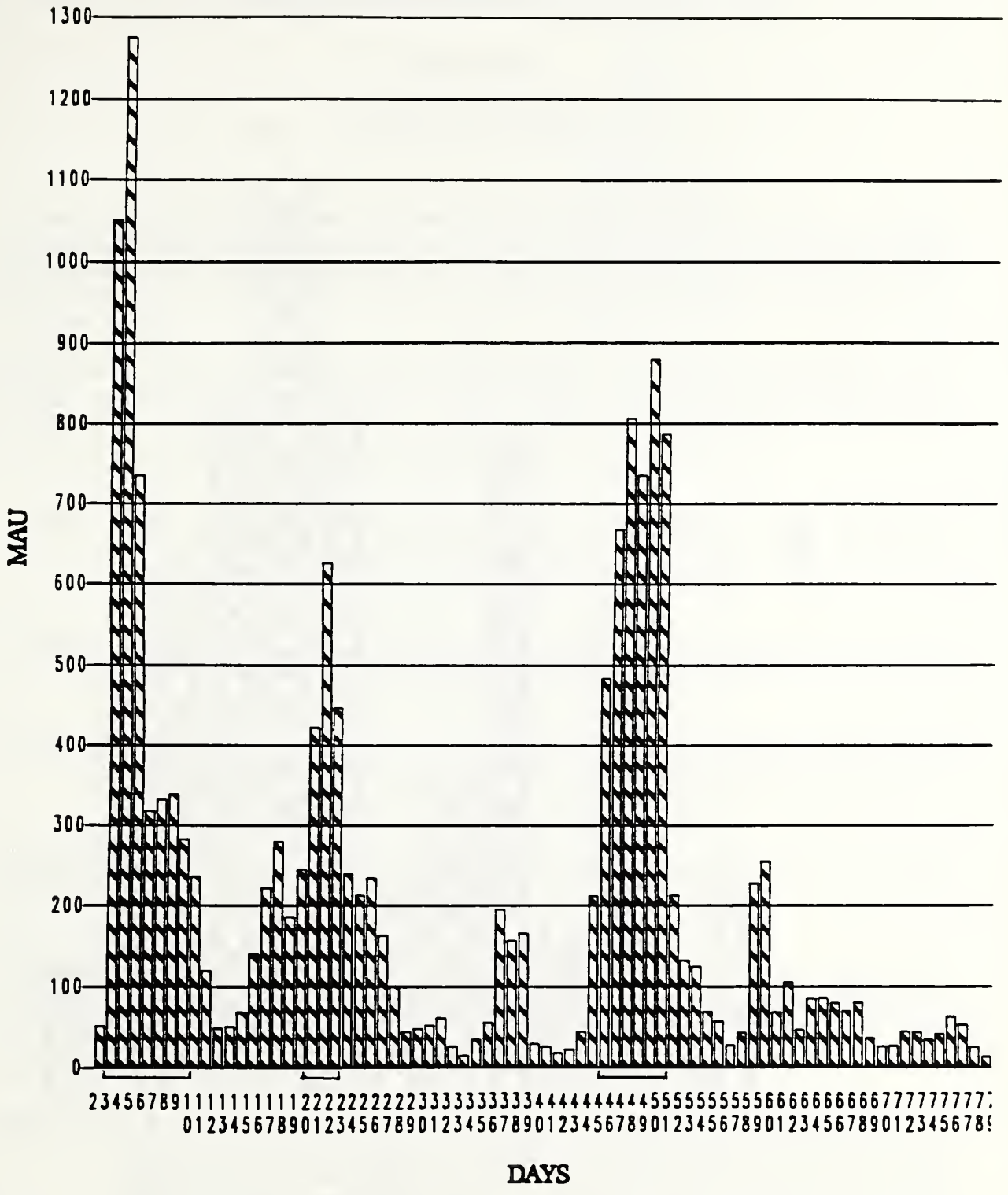
DAY 1 CORRESPONDS TO OCTOBER 1, 1993

FIGURE 4: AVERAGE SUGAR DEXTRAN FOR TECHE REGION



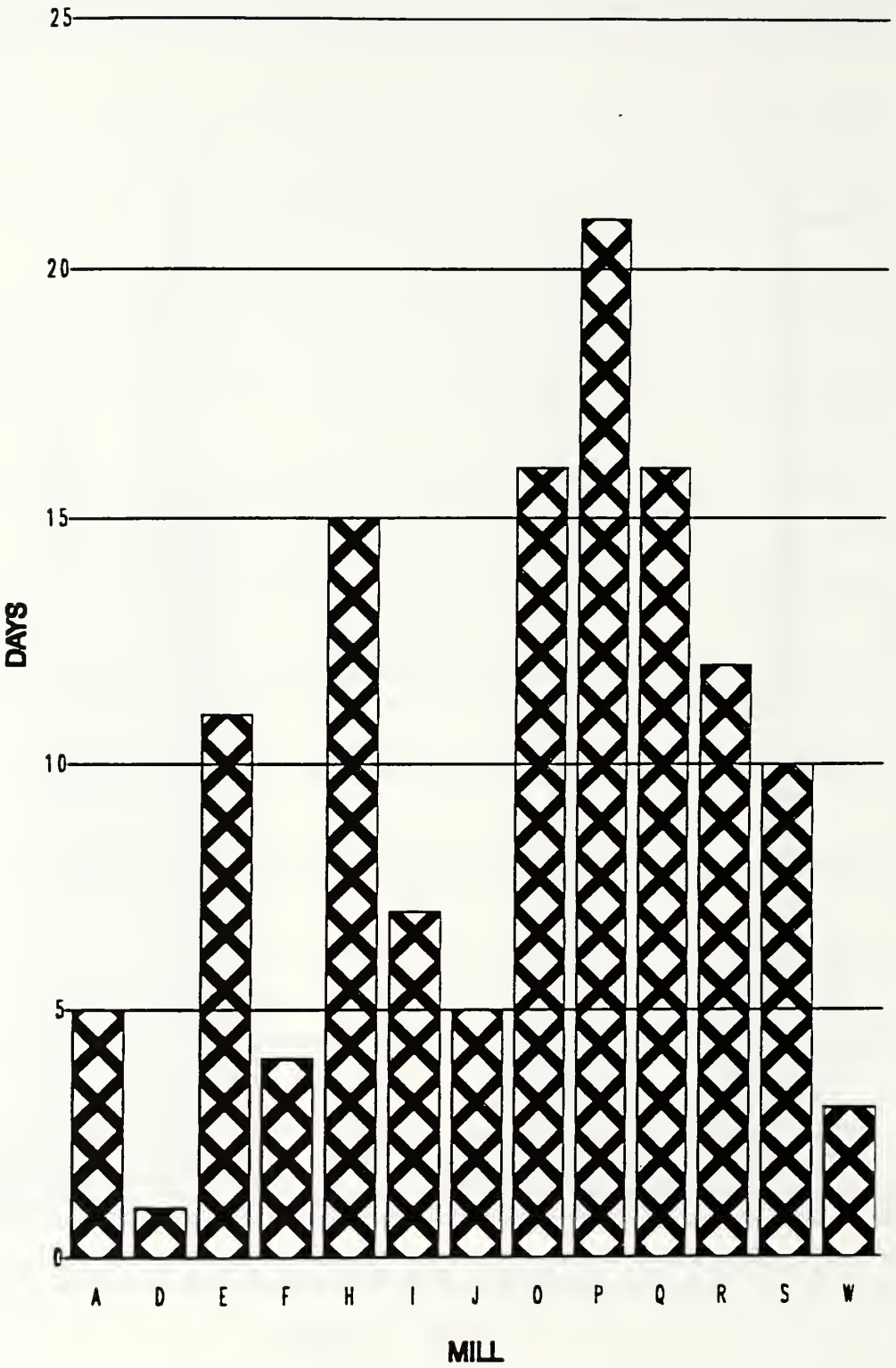
DAY 1 CORRESPONDS TO OCTOBER 1, 1993

FIGURE 5: AVERAGE SUGAR DEXTRAN FOR BAYOU REGION



DAY 1 CORRESPONDS TO OCTOBER 1, 1993

FIGURE 6: AVERAGE SUGAR DEXTRAN, MISSISSIPI REGION



LOUISIANA SUGAR MILLS, 1993 SEASON

FIGURE 7: DAYS ABOVE PENALTY LEVEL

STARCH AND DEXTRAN IN MOLASSES

Durriya Sarkar

Audubon Sugar Institute

We at Audubon Sugar Institute have been doing a molasses survey every year. Louisiana mills send their weekly molasses samples which are then analyzed for pol, brix, conductivity and sugars determined by HPLC. The target and true purities are calculated and the results sent to the mills weekly. The molasses received for the 1992 season were saved for determining starch and dextran values.

A new method for starch analysis was in progress but was not quite ready. After finalizing the procedure 180 molasses samples were analyzed. The starch was done by the new procedure and the dextran was determined by the ASI II method which was developed here a few years ago. The averages were calculated from the results of the molasses sent by 18 sugar mills. No correlation was seen between the starch and dextran values.

Figure 1: Average starch in molasses for the 13 weeks for the season. The starch values go down as the season progresses. This pattern is seen for all the mills. Some mills have low starch values as they use amylase during processing.

Figure 2: The Teche region mills show a pattern similar to the average for all the mills. Only one mill used amylase for a period of one month.

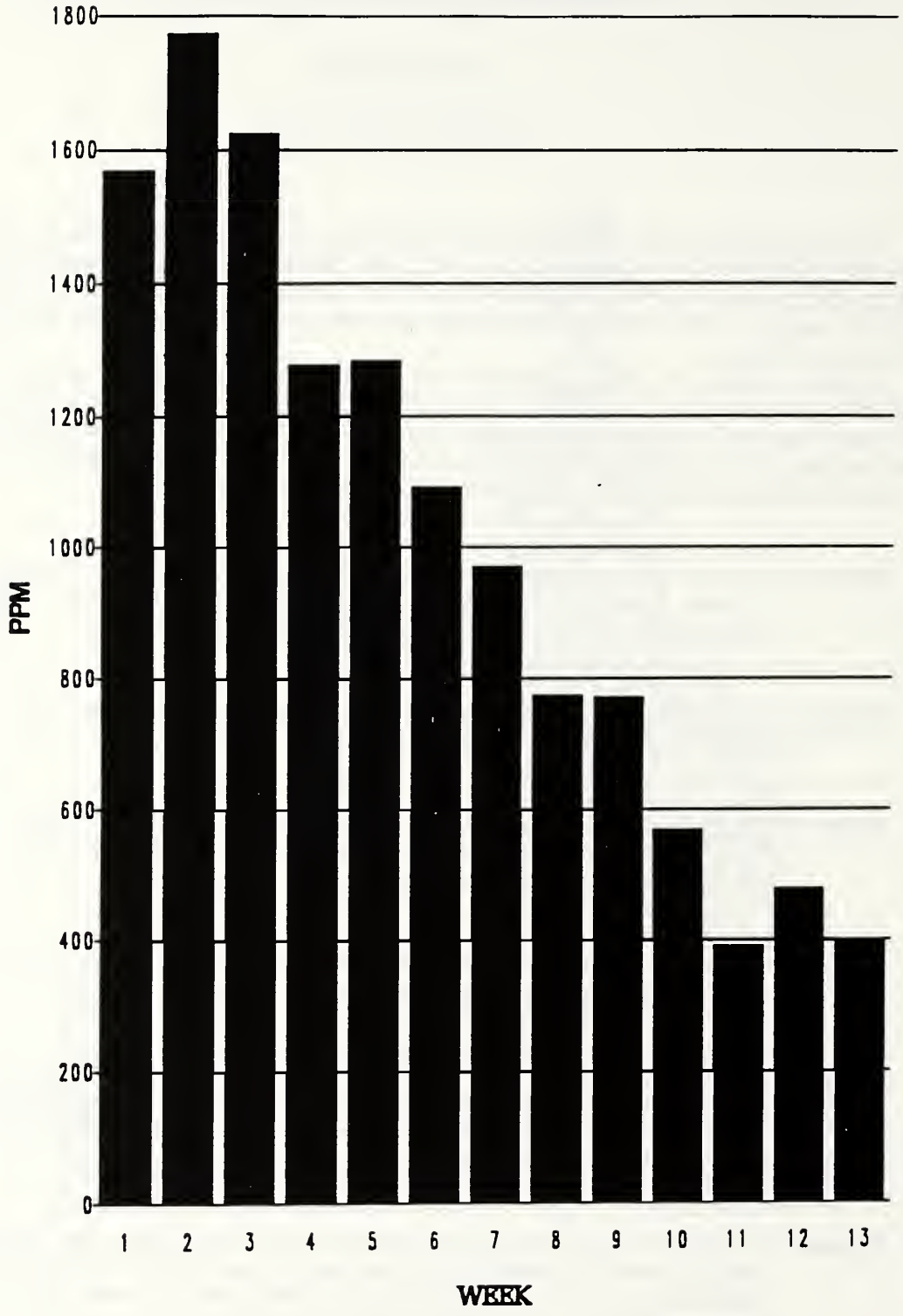
Figure 3: Higher starch levels are seen in the molasses in the Bayou region. None of the mills used amylase. One of the mills had low starch values which could be due to the fact that they filter their molasses.

Figure 4: The lowest values of starch were seen in the Mississippi region. Two out of five mills used amylase on a regular basis.

Figure 5: Dextran values go up after there is rainfall accompanied by temperatures of 50°F or above. Molasses dextran was high when sugar dextran was high. The highest value of the season for dextran of 6000 ppm occurred in molasses when sugar dextran was over 1000 MAU.

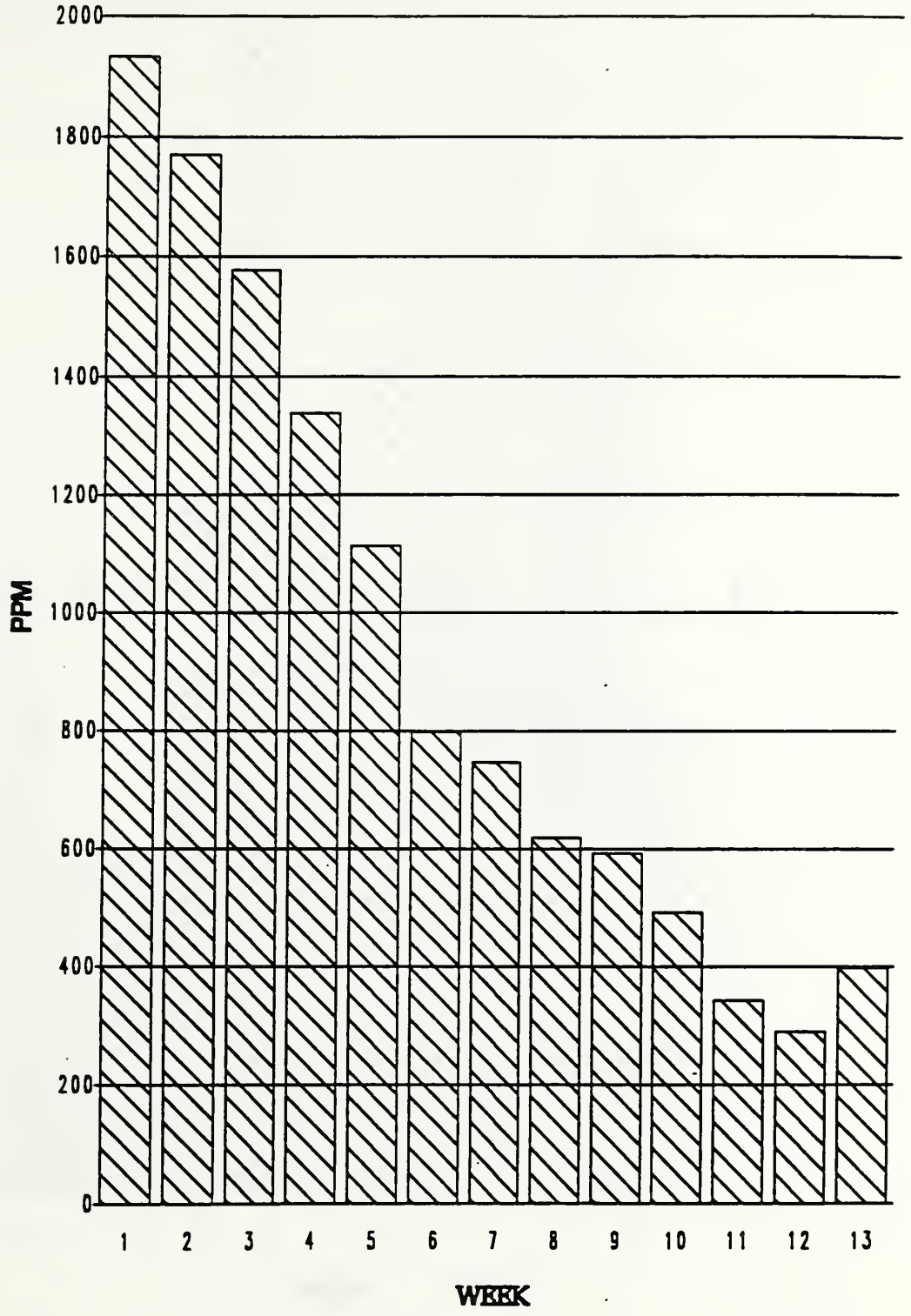
Figures 6, 7 & 8: These show the average dextran in the Teche, Bayou and Mississippi areas. We had more mills sending their molasses samples from the Bayou Lafourche and Mississippi areas than we had sending their dextran values for sugar. So the Teche region plot corresponds closely to the sugar dextran values we had for the season.

This project was partially funded by the American Sugar Cane League.



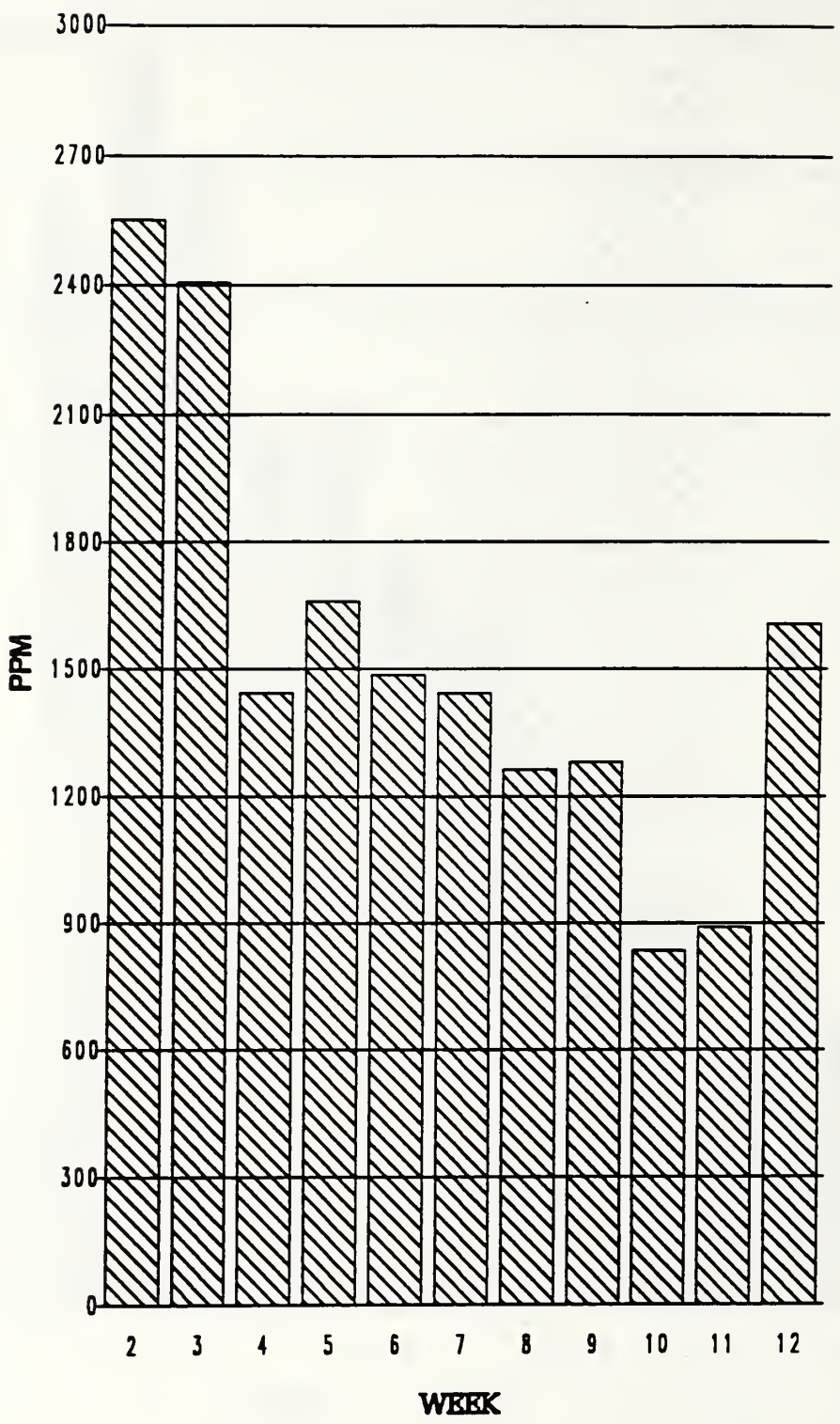
WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 1: AVERAGE STARCH IN MOLASSES, 1992



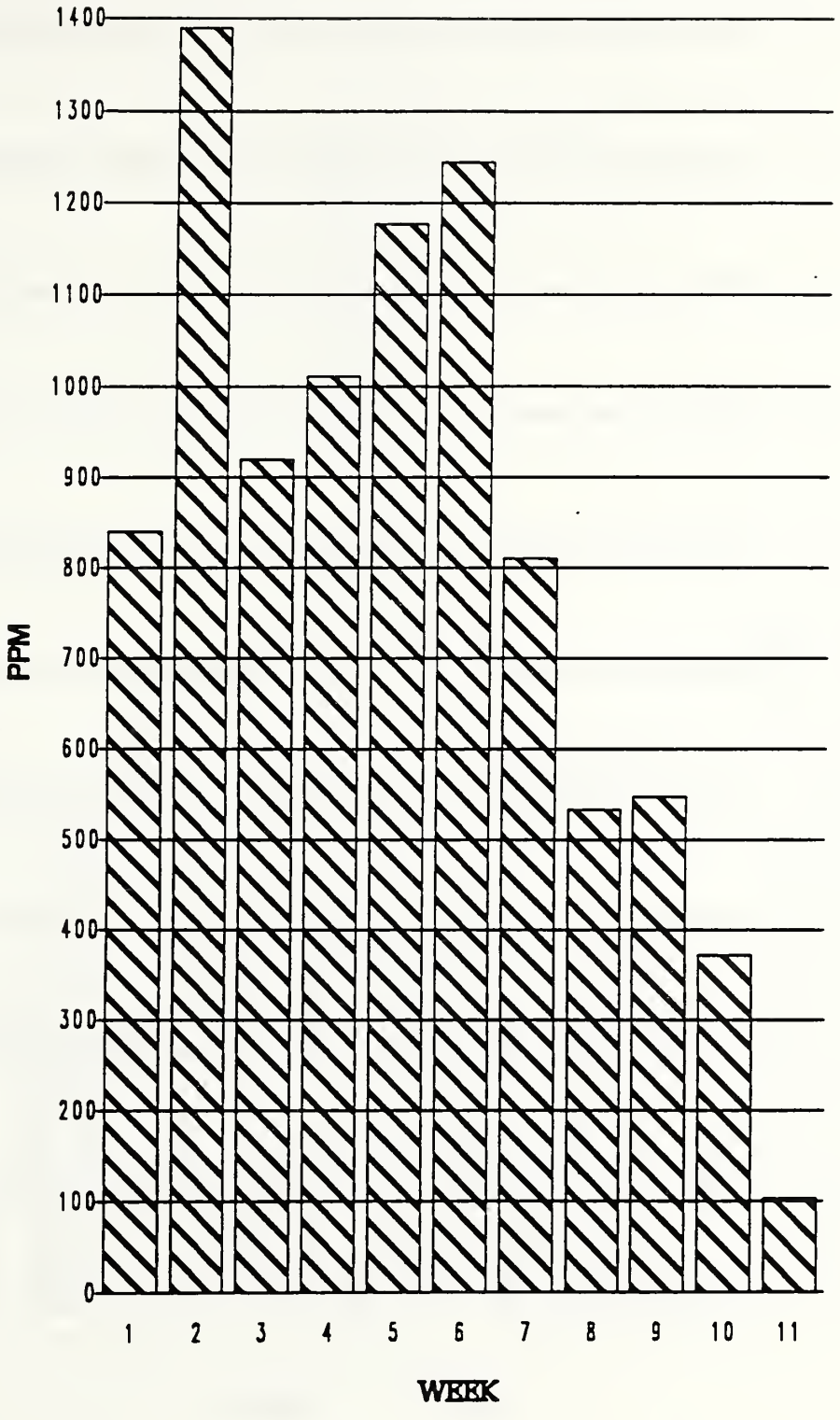
WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 2: MOLASSES STARCH, TECHE REGION, 1992



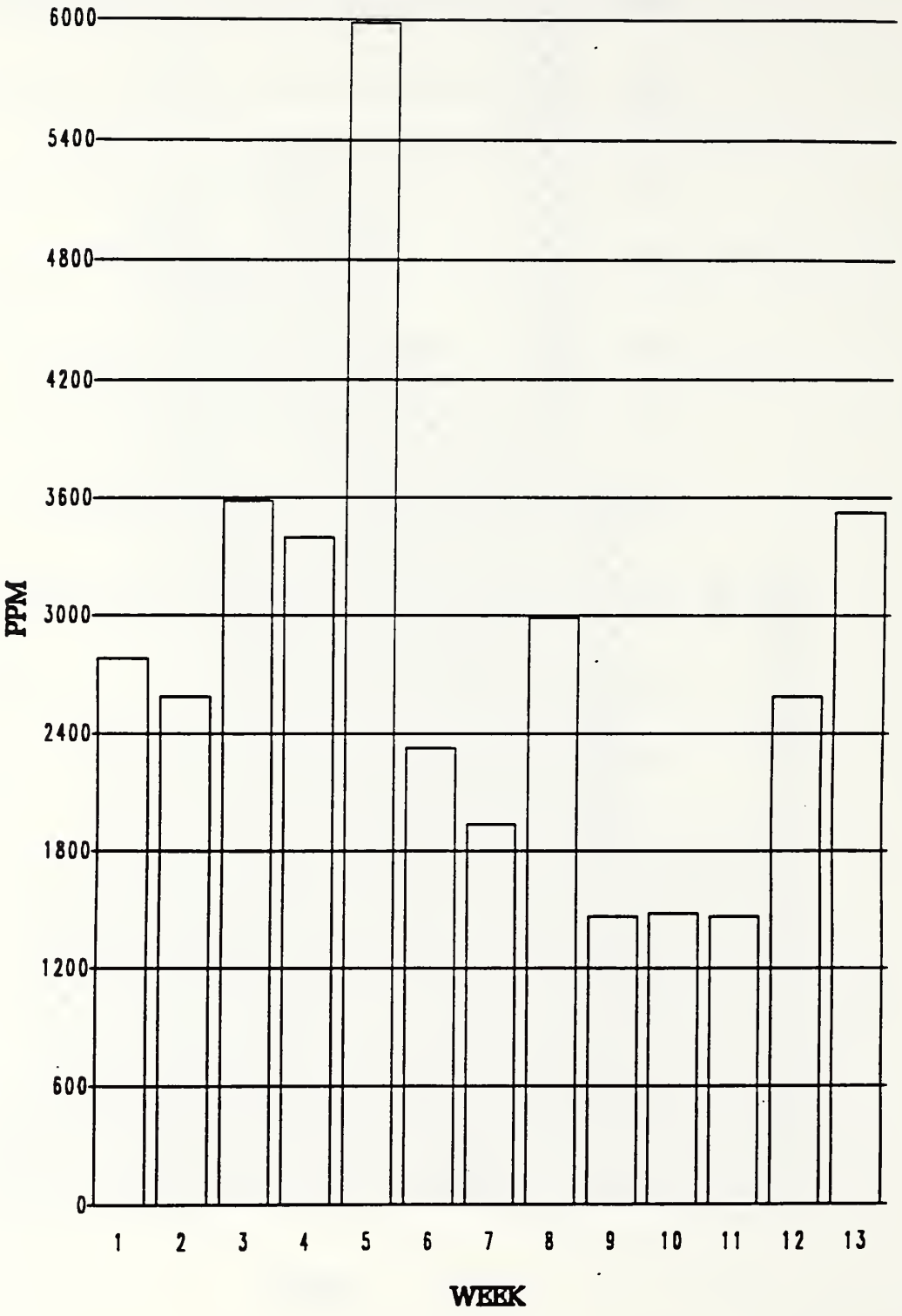
WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 3: MOLASSES STARCH, BAYOU REGION, 1992



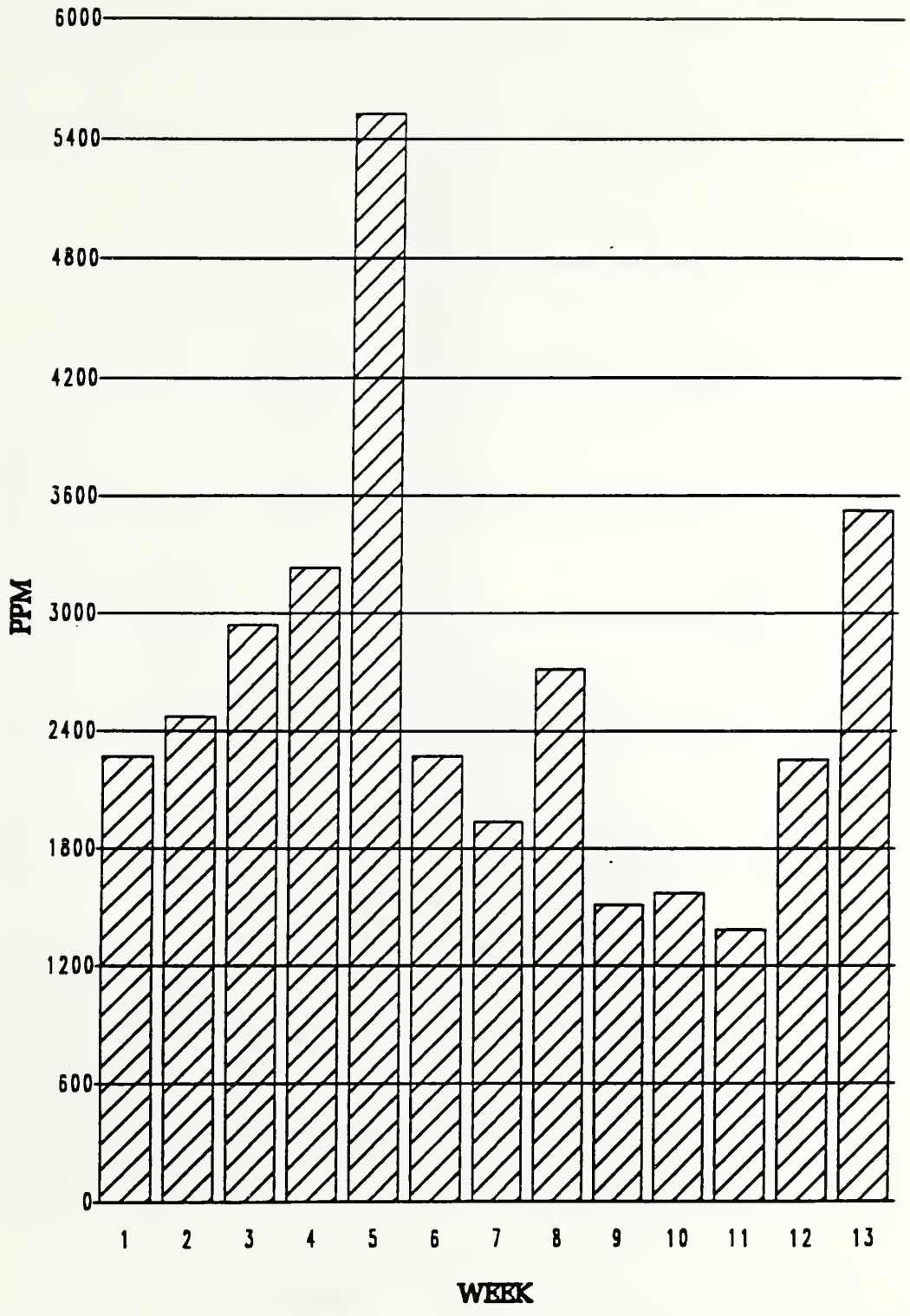
WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 4: MOLASSES STARCH, MISSISSIPI AREA – '92



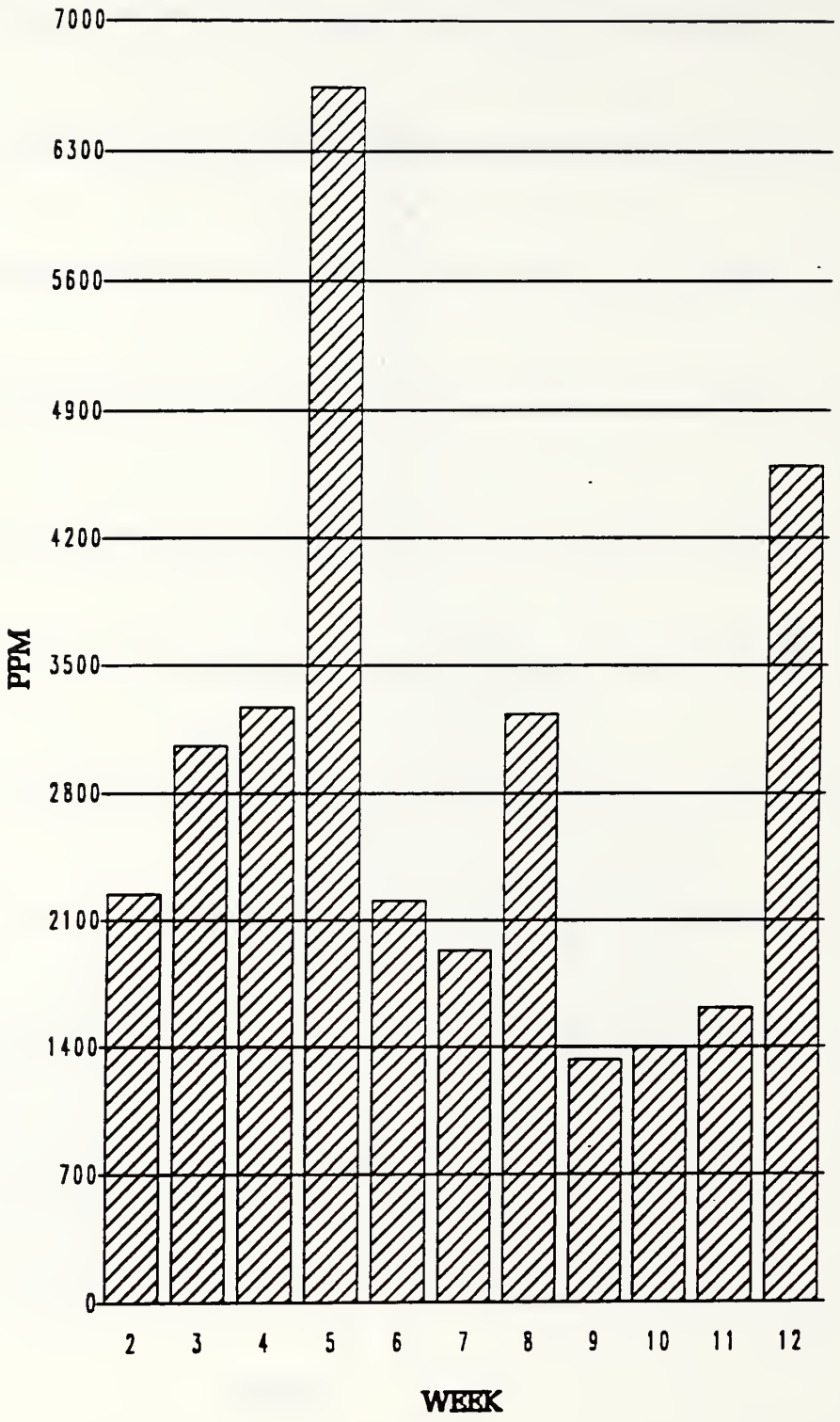
WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 5: AVERAGE DEXTRAN IN MOLASSES, 1992



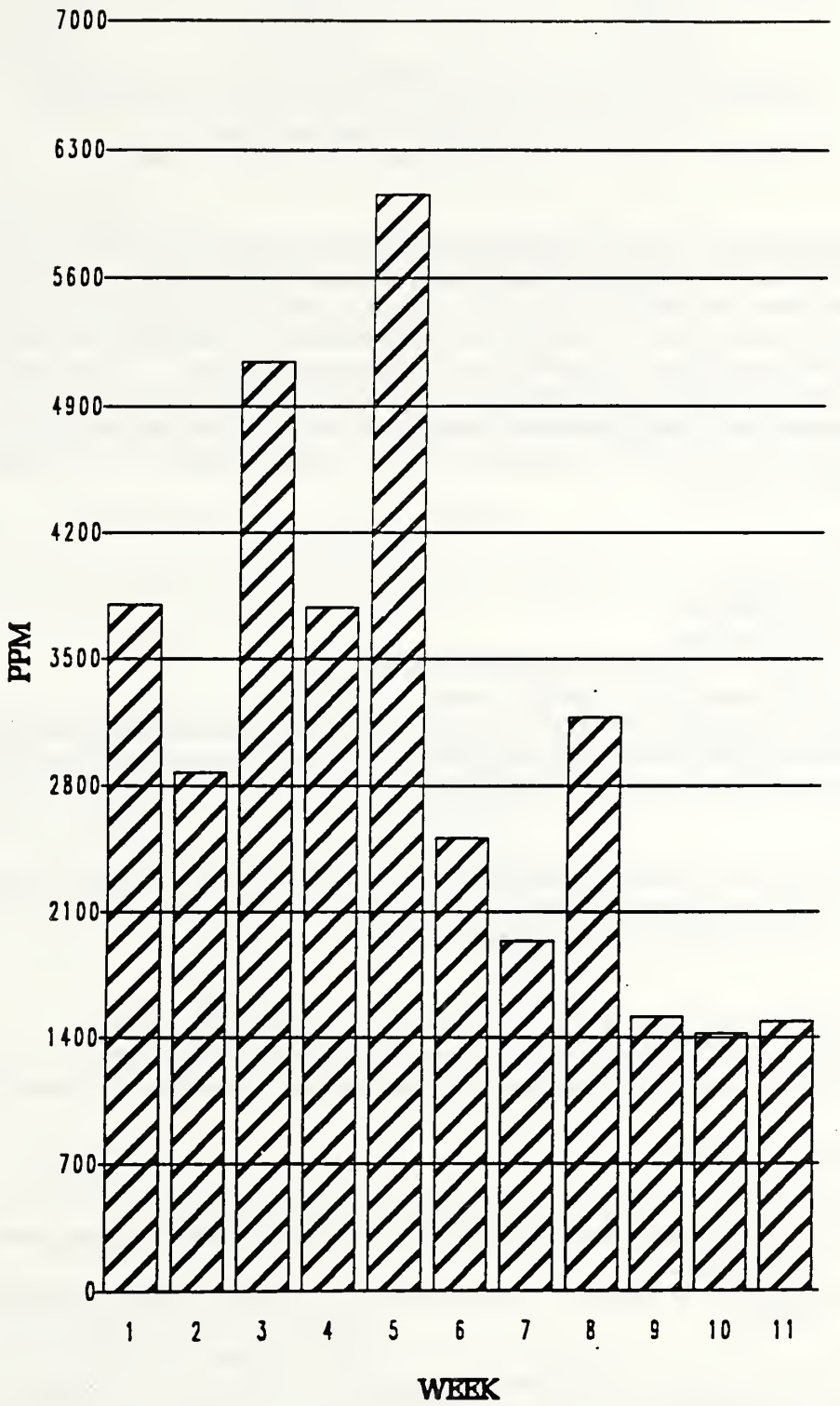
WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 6: MOLASSES DEXTRAN, TECHE REGION, 1992



WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 7: MOLASSES DEXTRAN, BAYOU REGION, 1992



WEEK 1 ENDS OCTOBER 10, 1992

FIGURE 8: MOLASSES DEXTRAN, MISSISSIPI AREA, –'92

ASI STARCH ASSAY

D. Sarkar and D.F. Day

Audubon Sugar Institute

Louisiana sugar mills have been having problems with presence of starch during processing. Some mills use an enzyme called amylase to alleviate the problem. The starch analyses that are being used now are complex and time consuming. A simple method has been developed in our laboratory which could be used at the sugar mills. It involves the use of amylase and iodine/iodate reagents. No precipitation of polysaccharides is involved as in the existing methods but the reagents used for the starch-iodine complex are identical. Juices, syrup, raw sugar and molasses have color which could give erroneous readings on the spectrophotometer. The amylase in the control tube hydrolyzes the starch giving a color blank for reading the starch value in the test.

Equipment:

Microcentrifuge: To centrifuge samples initially and at the end before reading on the spectrophotometer.
Analytical balance.
Water Bath: To incubate samples at 50°C.
Spectrophotometer: For reading samples at 570 nm.
Pipettes: Capacity to pipette 0.10 ml to 2.50 ml. (Automatic pipettes are very convenient)
Glassware: 100 ml volumetric flasks, beakers, 10 - 15 ml test tubes. marbles, cuvettes.
Microcentrifuge tubes 1.5 ml capacity.

Materials:

The enzyme and starch standard were purchased from Sigma Chemical Company, St. Louis.
α- Amylase enzyme: (Sigma A-0273) 10 mg/ml solution was prepared in water.
Starch: Soluble potato starch (Sigma S-2004).

Reagents:

2N Acetic Acid: 120 g of Glacial Acetic Acid in 1000 ml of water.
10% Potassium iodide solution in water. To be prepared fresh daily.
M/600 Potassium iodate: 0.03567 gms dissolved in 100 ml of water. To be prepared weekly.

Preparation of Sample:

Juice: Use as is.
Syrup: 1 part syrup is dissolved in 5 parts of water by weight.
Sugar: 15 gms of sugar are dissolved in about 50 ml of water and then the volume is made upto 100 ml.
Molasses: Dissolve 6 gms of molasses in about 50 ml of water and make up the volume to 100 ml.

Procedure:
1) The juice or the diluted syrup, sugar or molasses are centrifuged at 6000 rpm for 10 minutes.
2) Decant supernatant. Measure brix for juice, syrup and molasses. Sugar = 15 brix.
3) Pipette as follows in the 'control' tube and 'test' tube.

This project was partially funded by the American Sugar Cane League.

	Control	Test
Sample	1.0 ml	1.0 ml
Water	1.1 ml	1.0 ml
Amylase	-	0.1 ml

A reagent blank is set up using 1.0 ml water instead of 1.0 ml sample.

4) Mix. Top with marbles to prevent evaporation. Incubate at 50°C in a water bath for one hour.
5) Cool 10 minutes.
6) Add the following reagents and mix after each step.
   1.20 ml 2N Acetic Acid
   0.25 ml 10% Potassium Iodide
   2.50 ml M/600 Potassium Iodate
7) Centrifuge in microcentrifuge tubes at 6000 rpm for 5 minutes. Read the supernate at 570 nm. Read the test and the control against the reagent blank.
8) Test minus control gives the absorbance for the sample. The absorbance is read off of the standard curve to give the concentration of starch in ug/ml.

Calculation: $\text{PPM (on solids)} = \frac{100}{\text{Brix}} \times \text{ug starch}$

Starch Standard Curve

Determine the dry weight of soluble potato starch (Sigma S-2004) by drying 1.0 gm overnight at 100°C. Then using fresh starch, weigh a sample equivalent to 0.05 gms of dry weight. Dissolve by boiling in about 60 ml of water. Cool. Make up to 100 ml. Using this stock make up dilutions of 400, 300, 200, 100 and 50 ug/ml.

500 ug/ml Starch	Water
8.0 ml	2.0 ml
6.0 ml	4.0 ml
4.0 ml	6.0 ml
2.0 ml	8.0 ml
1.0 ml	9.0 ml

Set up as follows: (Similar results are obtained with or without amylase treatment.)

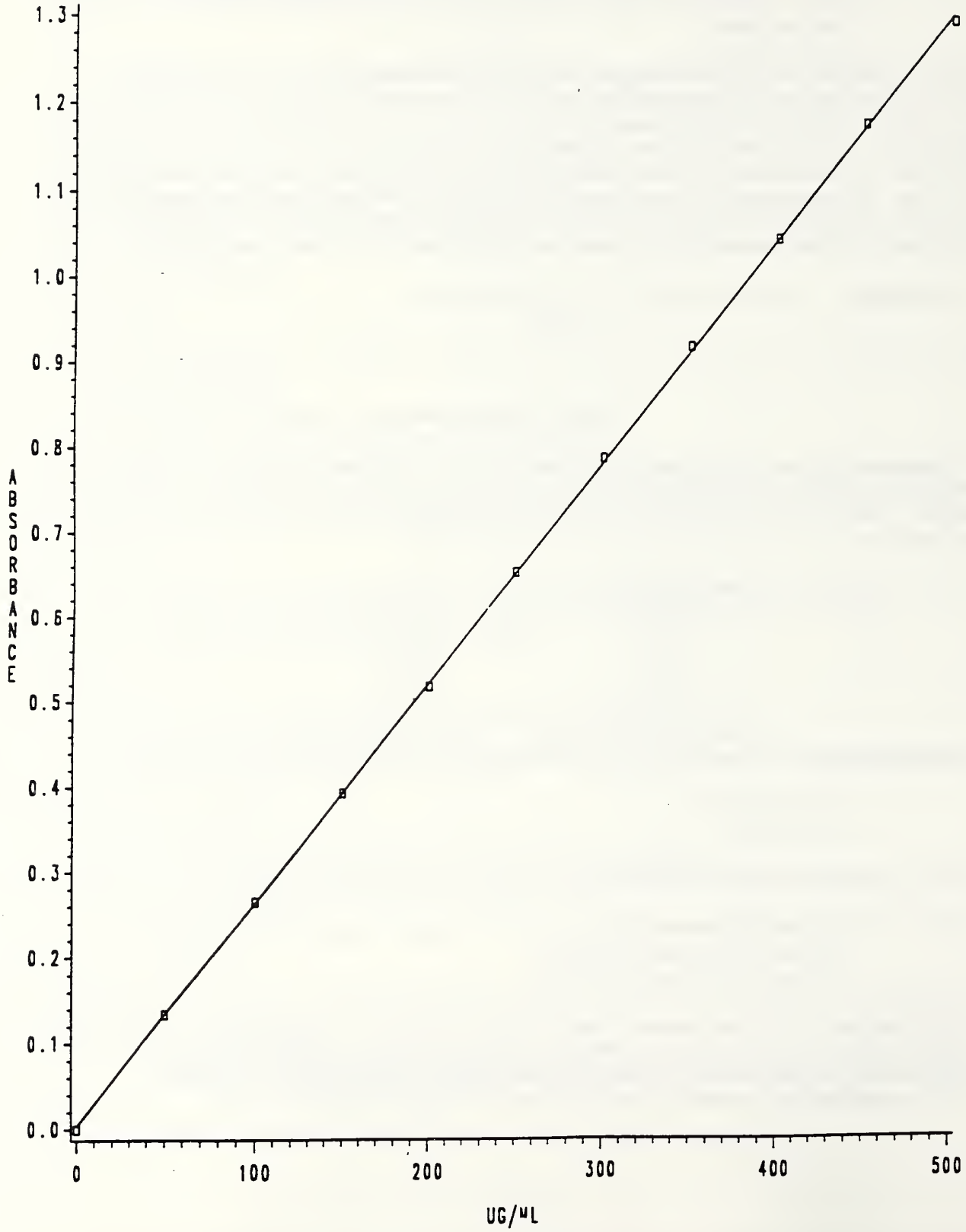
1.0 ml standard
1.1 ml water

Add, mixing at every step:

1.20 ml 2N Acetic acid
0.25 ml 10% Potassium iodide
2.50 ml M/600 Potassium iodate

Mix and read at 570 nm against a reagent blank which is set up substituting 1 ml of water for the standard. (If amylase controls are used the samples should be centrifuged before reading on the spectrophotometer, as amylase adds a slight opalescence to the sample.)
The concentration is plotted against the absorbance to give a standard curve.

STARCH STANDARD CURVE



CONCENTRATION AND DECOLORIZATION OF DILUTE PRODUCTS FROM CANE MOLASSES DESUGARIZATION WITH REVERSE OSMOSIS AND NANOFILTRATION MEMBRANES.

Michael Saska and Jean de Lataillade
Audubon Sugar Institute/Sugar Station

INTRODUCTION:

In the process of desugarization of cane molasses or cane refinery products, the three products, extract, invert and raffinate (Table I), have characteristically concentrations 40, 6, and 5 Brix, respectively (Saska and Lancrenon, 1993), and the cost of concentrating the two dilute streams may add 30 - 40 % to the direct operating cost of such a process. Any substantial reduction in the energy use would improve the prospects for commerciallization in cane sugar refineries or raw sugar mills that would operate the process in parts of the year when bagasse is not available. Reverse osmosis (RO) as an alternative to multi-stage evaporation has been considered before, for concentrating juice and dilute process streams (Merle, 1979; Bichsel and Sandre, 1982; Nielsen et al., 1982; Chou and Weber, 1988; Lee et al., 1989), but the current situation presents at least two apparent advantages with respect to RO of juice:

- the SMB products from feeds (molasses) that were clarified by ultrafiltration or were produced from ultrafiltered cane juice, are nearly completely free of turbidity, colloids, polysaccharides and gums (Table I). Such solutions are expected to require no further pretreatment prior to RO, and produce very little organic fouling of the membranes. For comparison, the clarified juice from a well run cane factory, tested and considered suitable for RO (Merle, 1979; Bichsel and Sandre, 1982) may have turbidities of the order of 20 NTU/Brix (200 ppm on Brix of suspended matter). The chances of inorganic fouling, from precipitation of divalent salts at the membrane surface would also be expected to be minimal, because of the partial softening of the SMB feeds.

- the concentrations are half, in the 5 to 15 Brix range, than in the concentration of juice from 15 to 25 Brix. The RO fluxes are inversely proportional to concentration, in a nearly linear fashion (Nielsen et al., 1982).

On the negative side, compared to RO fluxes with beet or cane juices, the flux of raffinate and invert will be reduced because of the higher osmotic pressures of salts and invert sugars in respect to sucrose (Figure 1). Generally, a permeate flux F ($l/m^2/hr$) through an RO membrane is proportional to the pressure differential between the imposed pressure P and the osmotic pressure π of the solution,

$$F = k (P - \pi)$$

where π is a function of the solution composition, concentration, and temperature and the permeability k, a function of the membrane properties, temperature, and the extent of fouling of the membrane surface.

Decolorization with nanofiltration membranes, with pore sizes ranging from 10 to 100

Å (as opposed to 10 Å or less for RO) has been studied before, mostly, it appears with respect to reducing the volume of waste waters and brine recovery in sugar refineries

Table I: Characteristic composition of invert and raffinate products from cane molasses desugarization process. The SMB feed, a sugarcane "C" molasses was clarified with the ASI cross-flow ceramic ultrafiltration system, and partially softened with a strong acid cation exchanger. Concentration (from IC) of the ions in g/kg DS.

	COLOR ICU	TURBIDITY NTU/Bx	SUCROSE %DS	INVERT %DS	Na	K	Mg	Ca
INVERT	25,000	0.5	5	85	0.2	2.0	0.0	0.0
RAFFINATE	500,000	1.0	14	4	9	120	2.5	0.7

(Wilson and Percival, 1990; Meadows and Wadley, 1992). Rejection of a component is related to its concentrations (g/l) in the permeate and concentrate/retentate (the part of the feed solution that does not pass through the membrane):

$$R = 1 - c_p/c_r$$

so that for a component too large to penetrate any of the pores of the membrane, $c_p = 0$ and $R = 1$. On the other hand, for very small molecules, e.g. those of the solvent, $c_p = c_r$ and $R = 0$. Since a large part of the colorants in the industrial sugar solutions are substantially larger than sugars, a suitable membrane with MWCO in the range 500 to 5,000 should have high rejection for colorants and low rejection for sugars.

Since the concentrate, i.e. the part of the feed that does not pass through the membrane, is in this case the waste stream, large residual concentrations in the final concentrate cannot be tolerated. In a multistage system, water can be added into the latter stages so that the sugar level in the final concentrate is reduced to an acceptable level. In a batch test, where the volume of diafiltration water D added (in liters) is such as to offset the permeate loss, the total volume F_0 is constant and the required volume of the (diafiltration) water is proportional to the rejection of the critical component (sucrose or invert). The rejection R of any component can be calculated from the decline of its concentration with D (or time), as

$$c_r = c_0 \exp [(D (R-1) / F_0]$$

CONCENTRATION OF SMB PRODUCTS WITH REVERSE OSMOSIS:

The flux vs. time curves of raffinate and invert products were measured in batch tests with a pilot system (Figure 2) consisting of a feed pump, a 5 micron pre-filter, two high pressure centrifugal pumps and two parallel pressure vessels, each holding one 5x96 cm (2x40") spiral wound element with a membrane area 2.05m^2, or 4.1 m^2 total. For all RO testing of raffinates and inverts, the membranes were the Osmonics SEPA SS10 made of cellulose acetate (Table II).

Some typical curves from batch concentrations of raffinate, run intermitttently with full permeate recycle in order to decouple the contributions to permeate flux decline from membrane

changes (fouling and compaction) and osmotic pressure rise, respectively are in Figure 3. Initial 50 minutes of the tests were run with full permeate recycle, so that no concentration occurs (Brix circa 4.0), and any flux changes are due to membrane fouling/compaction. Then, the permeate recycle is stopped, and

Table II: Characteristics of the RO and NF SEPA membranes used in this work (data from the manufacturer, Osmonics, Inc., Minnetonka, Minnesota).

NAME	POLYMER	%NaCl REJECTION	MWCO	MAX PRESSURE psi	pH RANGE	MAX T, C
SS10	CELLULOSE ACETATE	>98	150	1,000	2 - 8	50
HG05	POLYSULFONE	0	2,000	400	0.5 - 12	100

concentration is raised to about 6 Bx, and the testing repeated, until a concentration of around 13 Bx is achieved at the end of the test. When plotted vs. solution Brix (Figure 4 and 5), the dependence is linear (Table III), and the permeate flux reaches zero when the imposed pressure equals the osmotic pressure.

The rejection for invert sugars was characteristically around 99.5 %, for salts 99 %. The quality (salinity) of permeate from raffinate RO is comparable to tap water, with 30 - 50 ppm of monovalent cations (K^+ in case of raffinate permeate, and Na^+ in case of tap water), and sugar content below 5 ppm. In case of invert RO, the situation was reversed, with the sugar content 10 - 50 ppm and K^+ content below 5 ppm.

Table III: Permeate flux vs. Brix of sugarcane raffinate and invert, at 400, 600 and 800 psi. Flux ($l/m^2/hr$) = A - B x Brix.

		400	600	800
	A	16.6	22.6	27.8
INVERT	B	0.99	1.07	1.08
	A	12.4	18.4	23.0
RAFFINATE	B	1.22	1.34	1.34

Cleaning was done after each test by first rinsing with water, then cleaning for ca. 30 min. with the Osmonics' NP15 phosphoric acid based cleaning agent, at pH 2.5. The cleaning efficiency was checked prior and after each cleaning by measuring the permeate flux with water. After the initial few runs, where the water flux declined from circa 23 $l/m^2/hr$ (400 psi, 25 C, 30 l/min concentrate flow rate) to 15 $l/m^2/hr$, it stabilized and was easily recovered after each test with the short acid cleaning.

DECOLORIZATION WITH NANOFILTRATION MEMBRANES:

The tests were done on the same pilot as RO (Figure 2) with the Osmonics HGO5 2x40" polysulfone membranes, with a nominal MWCO 2,000 (Table II). Again, all tests were done in a batch mode, with one or more of the following employed during each test:

a) full recycle of permeate, i.e.constant concentration,

b) with no permeate recirculation, i.e. increasing concentration (in feed) of more retained components (colorants), and

c) at constant volume, with no permeate recirculation and diafiltration water added to the feed tank to maintain a constant level.

In longer runs, approximately 100 ppm of a formaldehyde solution was added to suppress microbial activity. The fluxes were measured, and samples of concentrate and permeate taken periodically and analyzed for sugars, ions and color. The rejections of the principal components, sucrose, invert sugars, ions, and colorants were calculated from the composition of corresponding permeates and retentates,

$$R = 1 - c_p/c_r$$

During diafiltration, after the initial decline (Figure 8), retentate color tends to reach a constant value, while color of the permeate drops within the same time to nearly zero. Clearly, some colorants are too large to penetrate any of the pores within the membrane, and we call this fraction COLOR 2, with R = 1. The smaller colorants, COLOR 1, does pass through the membrane and its average rejection R, can be calculated from the initial slope (Figure 8) of the diafiltration curves, as

$$\ln c_r = \ln c_{r0} + D(R-1)$$

where c's are proportional to the absorbance, measured at an appropriate dilution (420 nm, pH 7), but recalculated and reported later in this work (AU, 420) based on the original, undiluted sample.

To obtain more information on the two respective colorant fractions, a few nanofiltration runs were done with ultrafiltered SMB feed (sugarcane molasses), diluted to 5 - 7 Bx, and raffinate. The pore sizes of the SMB chromatographic resin and the HG05 membrane are comparable, in the range perhaps of 5 to 50Å. It follows then, that the size exclusion effect is likewise comparable: the molecules excluded by the membrane (COLOR 2) are also excluded by the resin during chromatography, and tend to concentrate with salts in the "fast" raffinate.

Flux data from several chronologically numbered tests at various conditions are in Figure 7. After the initial decline (test 1 - 3) with the new membrane, the flux has stabilized around 30 $l/m^2/hr$. The rapid flux increase at the end of test 4 is related to the dilution effect from the initial 16 Bx or so during difiltration at the end of the test. Acid cleaning after the long runs with NP15 (as with the RO membrane) restored the water flux. Color development, ln (absorbance at 420 nm), during the constant volume diafiltration (Figure 8) shows the initial decline while COLOR 1 is being washed out, followed, after all COLOR 1 has been removed, by a period of more or less constant retentate color. The initial slope, equal to (1-R) gives R of COLOR 1 of approximately 0.7, and independent within the limited accuracy of the experimental data of the type and total color of the feed material.

Rejections calculated from the retentate and permeate concentrations, of colorants, sugars and salts from tests 1,3,4,5, and 6 are plotted in Figure 9. The plotted data includes the periods of concentration and diafiltration, when c_p and c_r of permeating species (sugars, salts and COLOR 1) tend towards zero, and the error in calculating R becomes large. R for color tends to one, as the diafiltration or concentration progresses, and solution on both sides of the membrane is depleted of COLOR 1.

DISCUSSION/CONCLUSIONS:

Based on the flux correlation from Table III, an RO facility with five stages for concentration of 350 gpm of SMB raffinate (corresponding to a 400 T molasses/day desugarization plant) from 5 to 12 Brix was designed and is depicted in Figure 10. The concentrate from one stage becomes the feed for the following stage. Each stage consists of a decreasing number of parallel modules: 5, 4, 3, 3, and 2 respectively, and each module in turn is made up of six in-series 8x40" membrane elements (6 x 35 m^2 or 210 m^2), for a total membrane area of 3,600 m^2. The design limitations were:

- the pressure drop across a six element housing not to exceed 50 psig

- concentrate flow from the last element in a housing is not to be below 40 gpm and

- feed flow to any element is not to exceed 85 gpm.

With the pump efficiency 60% and motor efficiency 90%, the estimated power requirements for the feed and concentrate pumps P1 and P2 are respectively 335 and 170 kW. The energy recovery scheme where the concentrate from the third stage is used to boost the pressure of the feed from 600 to 800 psig, and the final raffinate concentrate is used in a turbine to boost the pressure of the feed to the fourth stage from 550 to 800 psig, is expected to reduce the required power by at least 20%.

At \$0.07/kWh, the energy cost is then on the order of \$0.63/m^3 of permeate, compared to \$1.00 - \$1.20/m^3 for quadruple effect evaporation. For membrane lifetime of one, two and three years, at about \$1,000 per one 8x40" element (\$28/m^2), the membrane replacement cost is \$0.25/m^3, \$0.12/m^3, and 0.08/m^3 giving a total operating cost \$0.88, \$0.79, and \$0.71/m^3. Capital cost estimated for this facility is \$650,000 - \$750,000 (Gould, 1994).

As the choice of membrane was not optimized here, it is quite likely that better performance in terms of permeate fluxes would be obtained with looser (higher MWCO) and higher temperature membranes, e.g. the Osmonics SEPA-M polyamide based membranes, with maximum operating temperature 80 C. Nielsen etal. (1982) saw the flux double in tests with beet thin juice when temperature was raised from 40 to 80 C, and although there may be little interest in going above 70 C or so (Bichsel and Sandre, 1982), because of shortened membrane life, more membrane compaction and increase in osmotic pressure, raising the permeate flux by another 50% over the ones found here, would bring the operating expenses down to the very competitive range \$0.47/m^3 to \$0.59/m^3.

An N stage design of a decolorization line (nanofiltration) where the concentrate from

one stage becomes the feed for the subsequent stage, water is added to the concentrate in one or more stages and permeates from all stages are mixed, is depicted in Figure 11. Based on the average flux 30 l/m^2/hr, pressure 100 - 150 psig), rejections 0.2 for sugars, 0.7 for COLOR 1, and 1 for COLOR 2, a design for 100 gpm (400 t molasses/day) of 5 Bx solution (feed), with six stages, of which last three are operated in the diafiltration mode is in Table IV. The corresponding compositions, in respect to the concentrations of the three principal components (relative to the feed) of the products (retentate and permeate) from each stage are in figures 12 and 13. For a conservative estimate of the decolorization effect in an invert decolorization line, only COLOR 1 fraction is considered, assuming, as discussed previously, that the completely rejected COLOR 2 is primarily in the raffinate product from SMB, and color in invert is primarily type 1 (R = 0.7), the decolorization effect is 30% and equals the amount of COLOR 1 in the final concentrate (from stage 6) relative to that in the feed. Similarly, sugar loss in the final concentrate is 4.3 %.

The major part of the operating costs of this decolorization line will consists of the energy for the 150 psi pumps, membrane replacement cost and expenditure to remove from the permeate the diafiltration water added into the last three stages. With three pumps, on the feed, and after stages 2 and 4, the total estimated power requirement is 30 kW or \$0.08/m^3 permeate. At circa \$800 per one 8x40" element (polysulfone HG05 membrane), or \$23/m^2, the total membrane cost is \$20,000, and the replacement cost, with 1, 2 and 3 year life span respectively, \$0.12, \$0.06 and \$0.04/m^3. At the evaporation cost of \$1.20/m^3 water, and the diafiltration volume circa 20 % on the feed volume, the evaporation cost is \$0.26/m^3 permeate. Altogether, the anticipated operating cost is then between \$0.38 - \$0.46/m^3 or \$0.008 - \$0.009 per kg of sugar produced. Naturally, nanofiltration cannot give full decolorization, as some colorants are not separable from the sugars based on size, but the reduction of the load on the subsequent resin or carbon operation would be significant, at a cost that appears highly competitive with an anion exchange/carbon decolorization.

Clearly, despite the effort to be conservative with the cost estimates, extended testing is required to strengthen these predictions. On the other hand, with respect to decolorization, the fluxes can very likely be raised substantially by running the filtration at 60 C - 70 C. The limiting factor in this work was not the polysulfone membrane that can tolerate higher temperatures (Table II) but rather the high pressure centrifugal pumps. Furthermore, the solid flux (kg DS/m^2/hr) may be higher at higher Brixes than the 5 - 10 Bx range tested here. In case of ultrafiltration, it is found that filtration of final molasses at 30 - 40 Brix maximizes the solid flux.

Table IV: A six stage design of a membrane decolorization line, assumed average permeate flux 30 l/m^2/hr, 100 - 150 psig, 100 gpm of dilute feed.

STAGE No.	1	2	3	4	5	6
No. MODULES IN PARALLEL	2	1	1	1	1	1
ELEMENT SIZE	8x40"	8x40"	4x40"	4x40"	4x40"	4x40"
TOTAL AREA,m^2	420	210	54	54	54	54
RETENTATE,gpm	46	18	10	10	10	10
PERMEATE,gpm	57	28	7	7	7	7
WATER IN STAGE No.,gpm	0	0	0	7	7	7

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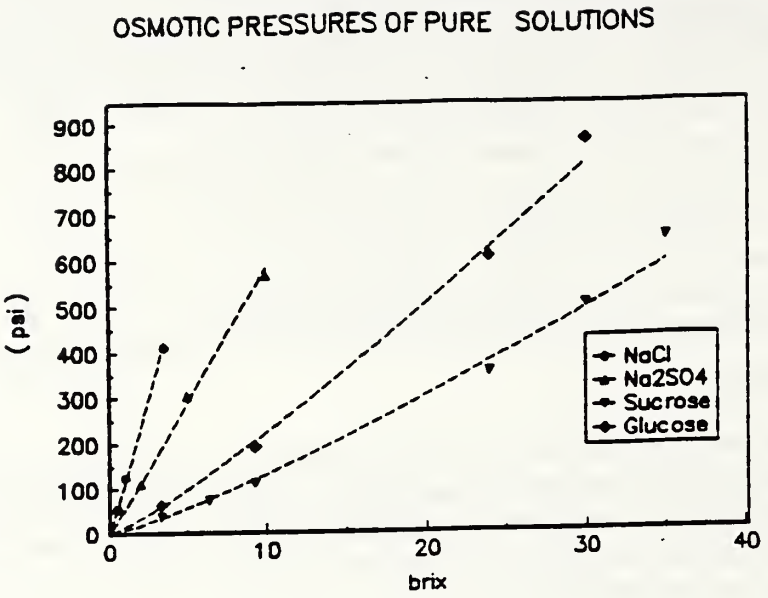

Figure 1: Osmotic pressure vs. composition of pure solutions: NaCl, Na2SO4, sucrose and glucose.

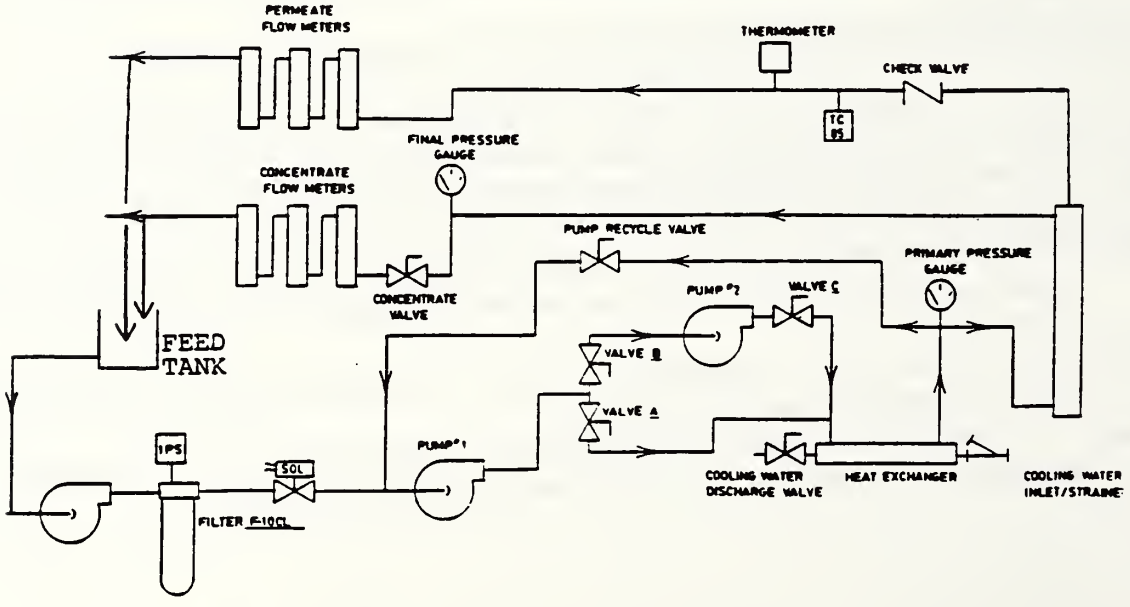

Figure 2: Schematics of the Audubon Sugar Institute RO/NF pilot installation.

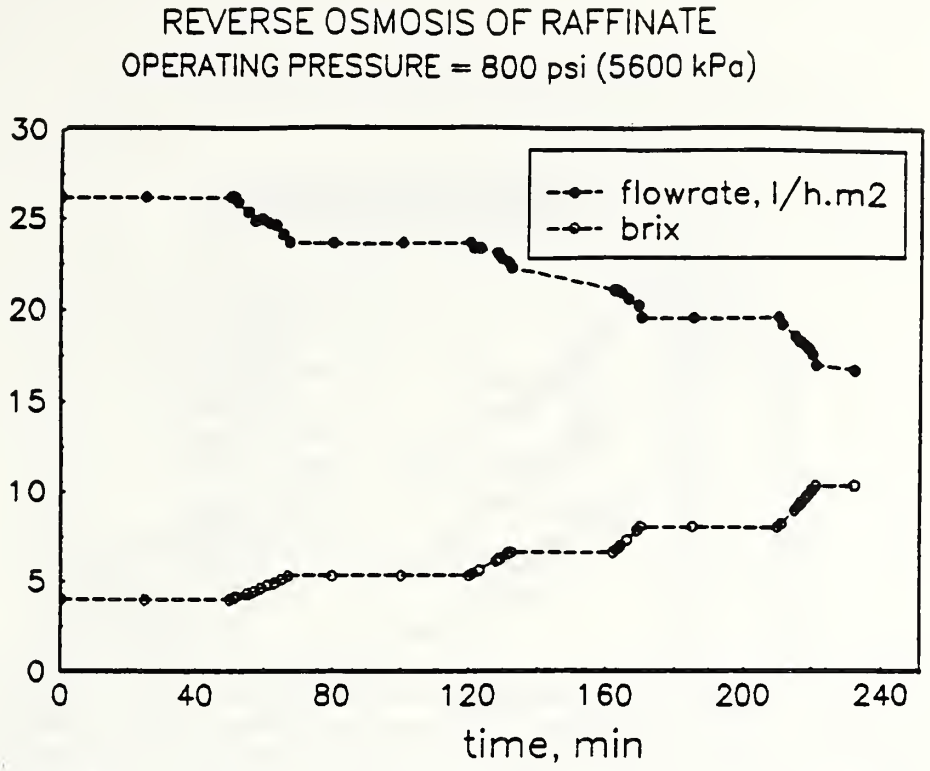

Figure 3: Permeate flux. vs. time during batch concentration of raffinate, at 800 psi, 40 C, SS10 membrane (2 x 2.05 m2). With intermittent full permeate recycle into the feed tank.

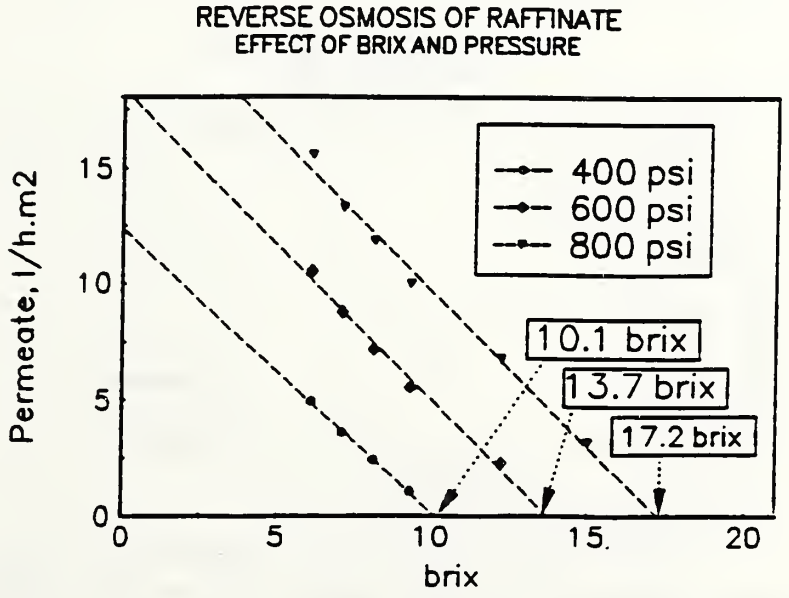

Figure 4: Permeate flux vs. Brix, raffinate, at 400, 600 and 800 psi, 40 C, SS10 membrane (2 x 2.05 m2).

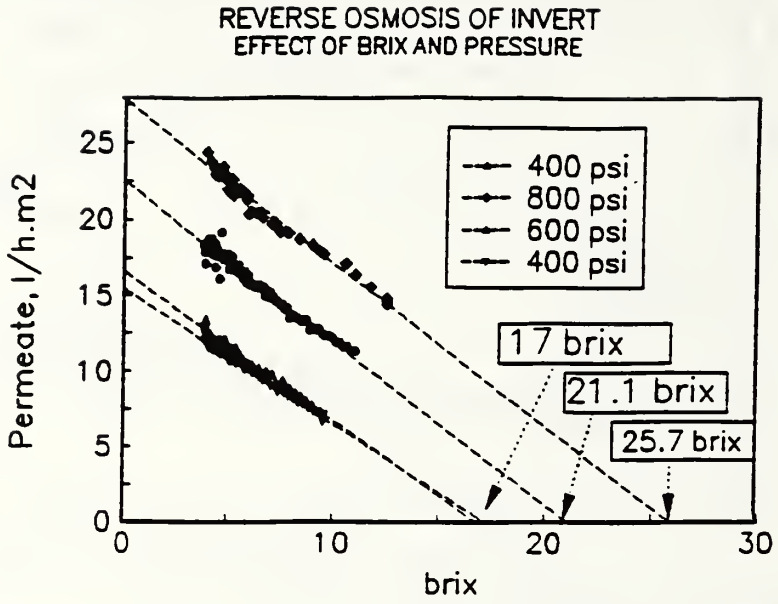

Figure 5: Permeate flux vs. Brix, invert, at 400, 600 and 800 psi, 40 C, SS10 membrane (2 x 2.05 m2).

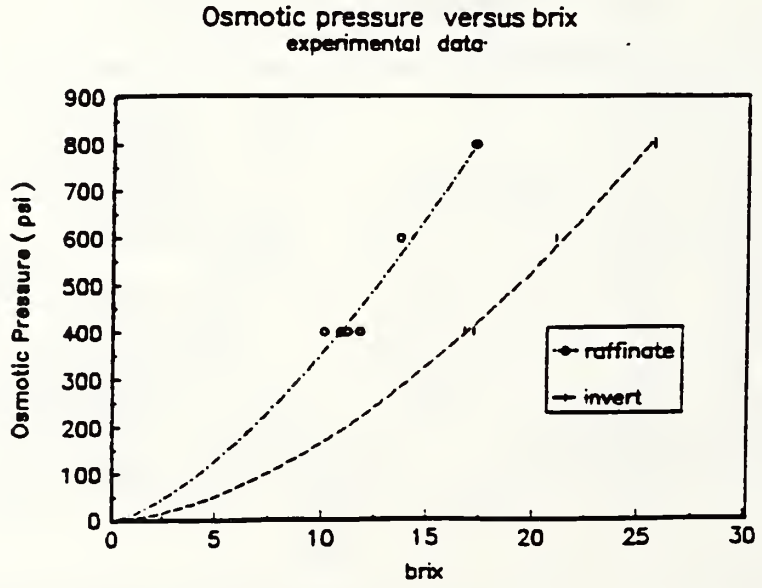

Figure 6: Osmotic pressure of sugarcane raffinate and invert vs. solution concentration at 40 C.

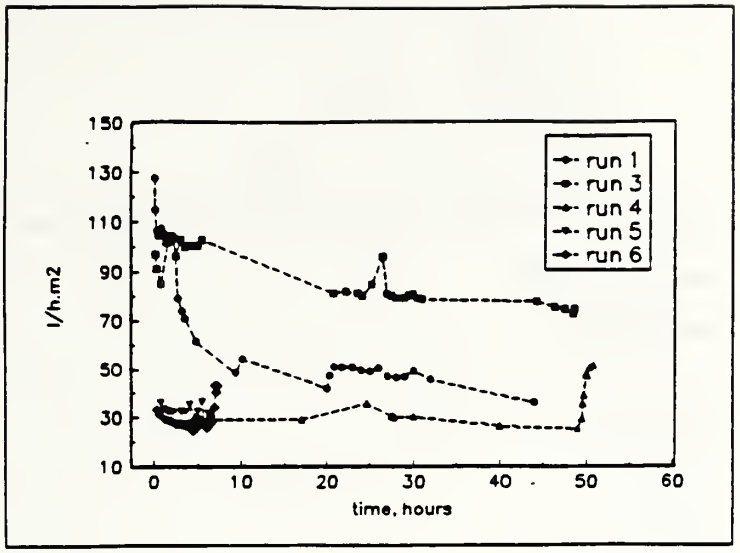

Figure 7: Nanofiltration flux vs. time, dilute sugar solutions. Test conditions: Run No. 1 = invert, 7 Bx, 100 psi. 3 = invert, 6 Bx, 300 psi. 4 = invert, 16 Bx, 100 psi. 5 = SMB feed (ultrafiltered), 6 Bx, 100 psi. 6 = raffinate, 5 Bx, 100 psi.

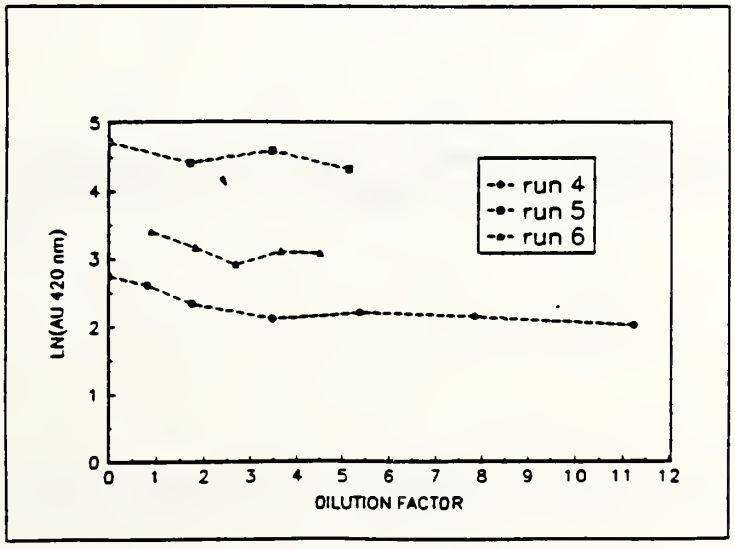

Figure 8: Color (AU) of the nanofiltration concentrate, during diafiltration. Test conditions as in Figure 7.

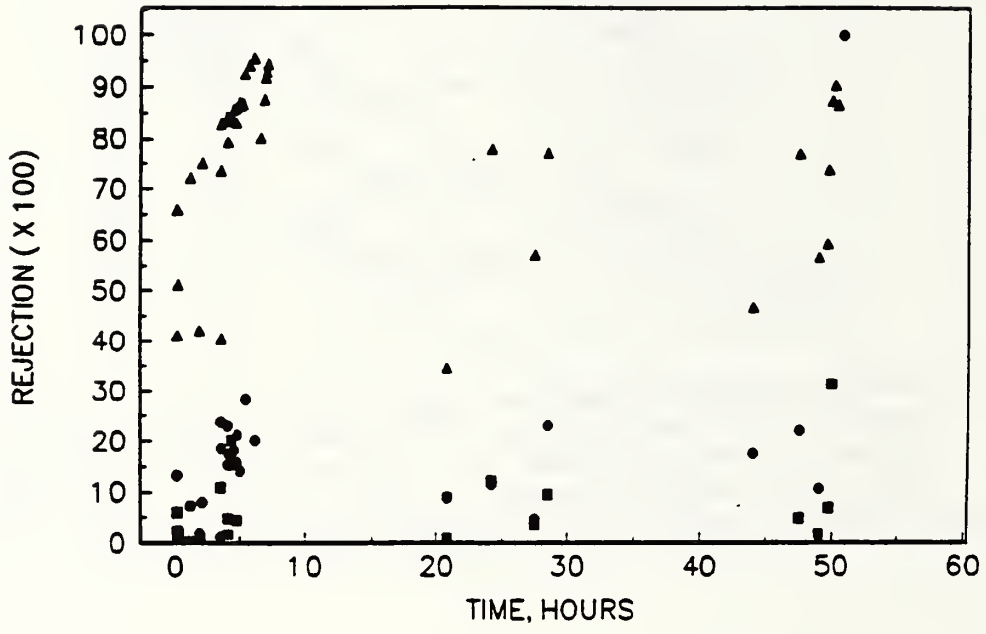

Figure 9: Rejection of sugars, salts and colorants. Test conditions as in Figure 7. ▲ color, ■ sugars, ● salts.

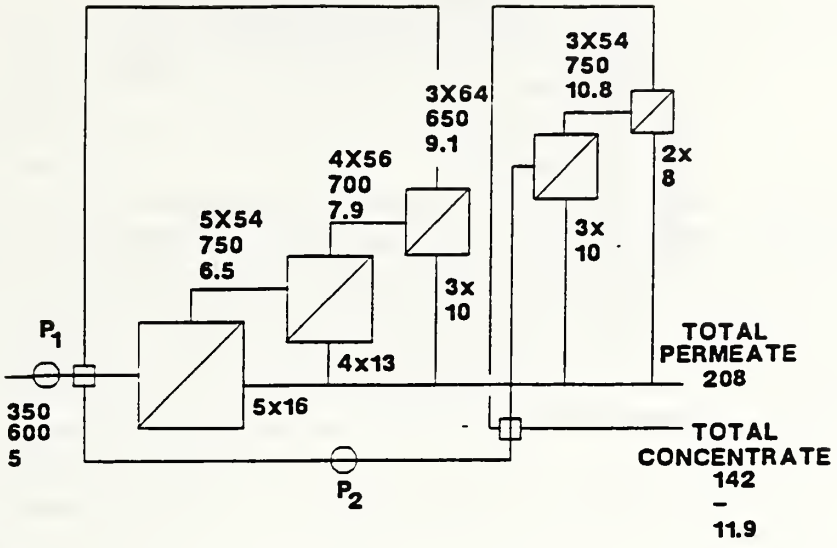

Figure 10: A five stage design of an RO line for concentration of 350 gpm of dilute raffinate. Permeate flux is the function of Bx from Table III. The numbers on the feed and concentrate lines give the flow in gpm, pressure in psig and Bx. Flow rate in gpm on the permeate lines.

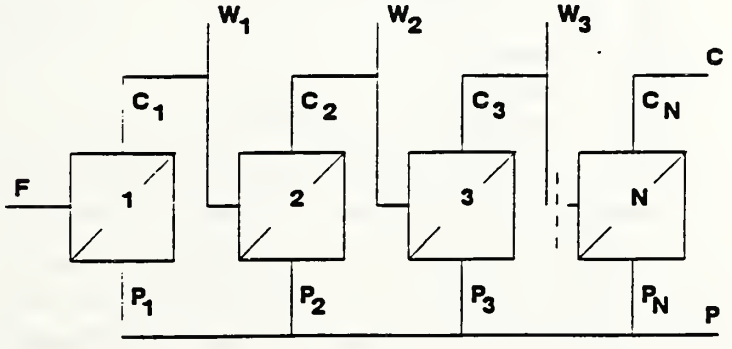

Figure 11: An N stage design for a nanofiltration line, with diafiltration.

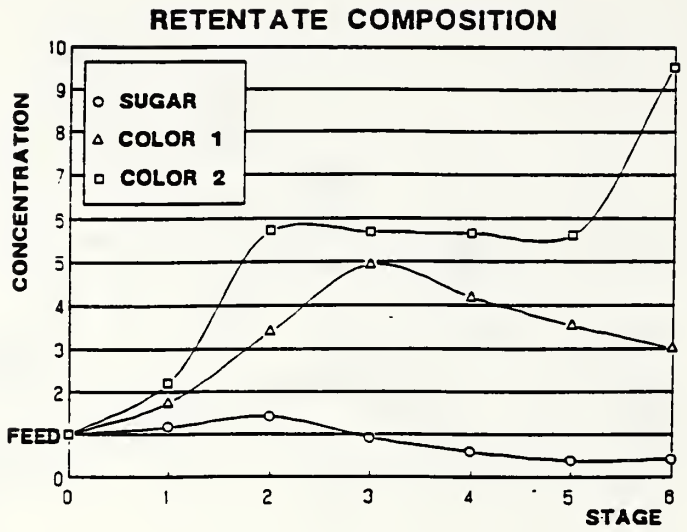

Figure 12: Predicted retentate composition in a six stage decolorization line (Table IV). Rejections: R(sugars) = 0.2, R(COLOR 1) = 0.7, R(COLOR 2) = 1.

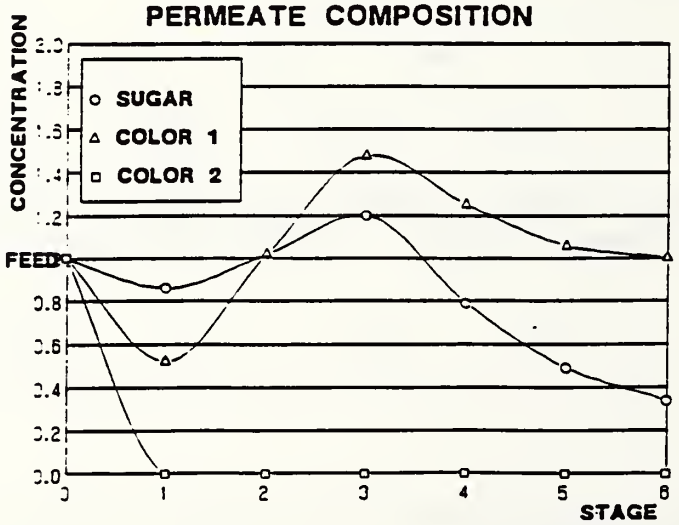

Figure 13: Predicted permeate composition in a six stage decolorization line. Other parameters in Table IV and Figure 12.

AQUEOUS EXTRACTION OF SUGARCANE BAGASSE HEMICELLULOSE AND PRODUCTION OF XYLOSE SYRUP.

M. Saska and E. Ozer
Sugar Station/Audubon Sugar Institute

INTRODUCTION:

Among the several potential biomass sources, sugarcane bagasse has frequently been mentioned in the literature as one of the most promising for the biomass-to-sugars process, for fuel grade ethanol or other uses. It was estimated (Reid and Rein, 1983) that without resorting to supplemental fuels, the existing sugarcane mills could free up 35 to 45% of the total bagasse produced for alternate uses if sufficient economic incentives were in place. The $30 to $40/t (dry) cost estimate (Bozell and Landucci, 1993; Purchase et al, 1990) for bagasse at the mill site, with zero transportation cost, based on its fuel replacement value, is too high for the first 10% (or 0.5 million tons annualy in U.S., Table I) or so that can be diverted without any significant investments on the part of the sugar producers. The net cost of the next 25 to 35 % of the total bagasse production (1.1 to 1.6 million tons per annum) will depend on the cost of the high efficiency boilers, vapor recompression units, etc. (Reid and Rein, 1983) that will be needed to bring about the required energy savings, but should still be below the fuel replacement value. Only if even more bagasse is required for alternate uses, the $30 to $40/t (dry) estimate will apply.

Table I: Estimated U.S. bagasse production, in million tons (dry) per annum.

	1991	1992	1993
FLORIDA	2.4	2.3	2.3
LOUISIANA	1.0	1.2	1.2
HAWAII	0.9	0.8	0.8
TEXAS	0.1	0.2	0.2
TOTAL U.S.	4.4	4.5	4.5

The currently preferred conversion process (Bernhardt and Proudfoot, 1990; Torget et al., 1990) involves prehydrolysis with 0.5 to 1.0 % dilute sulphuric acid at 100 - 130 C to solubilize most of the hemicellulose, which is then converted with xylose fermenting microorganisms. At the same time, cellulose, swollen and decrystallized to some degree, is made accessible to hydrolysis with enzymes or strong acids. Simultaneous enzymatic saccharification and fermentation (SSF) is the most promising of processes for conversion of the pretreated cellulose to ethanol (Spindler etal, 1990). Based on the conditions of Bernhardt and Proudfoot, the pretreatment cost including sulphuric acid, lime to neutralize the liquor and gypsum disposal, but excluding energy and capital costs, is estimated at $0.014/kg bagasse (dry) or, with cellulose hydrolysis, $0.028/kg sugars. Although the required amount of sulphuric acid is relatively small, its recovery would be desirable if it could be done economically. This does not appear feasible from the dilute hydrolysates generated in this process. Furthermore, concentration of the acidic hydrolysates with 2 to 4 % sugars and 0.5 to 1% sulphuric acid to at least 10% sugars for

efficient fermentation would be expensive because of the severe corrosion problems with common construction materials. An alternative is steam/aqueous pretreatment, either in a high pressure steam-explosion equipment (Avellar etal, ; Jollez etal, 1992) or in more conventional lower pressure continuous or batch digesters. The latter was used in this work. Because not all extracted hemicellulose is hydrolyzed to sugars in the steam/aqueous pretreatment at the optimum severities for hemicellulose extraction, post extraction hydrolysis with sulphuric acid of the concentrated extracts was investigated. The recovery of sulphuric acid from the low volume, concentrated hydrolysates becomes then feasible. Separation of the acid by ion exclusion chromatography on strong cation exchangers appears most promising, and has been tested previously on single column (Hartfield and Hester, 1993) and continuous multi-column systems (Rossiter, 1993). An 8 column simulated moving bed pilot unit was used here to optimize the recovery of sulphuric acid from the concentrated pretreatment hydrolysates. Of even more interest than in the bagasse pretreatment where the acid consumption is modest, is of course recovery of sulphuric acid from the glucose liquors from the concentrated acid hydrolysis of cellulose where the acid recycle is a pre-condition for economic viability (Hartfield and Hester, 1993). The acid-sugar separation optimized here for concentrated pretreatment liquors is directly applicable as well for the cellulose hydrolysates, with the exception of the construction materials that will have to be designed such as to withstand the highly corrosive hydrolysates with 20% or so of sulphuric acid.

The enzymatic or acid digestibility of pretreated cellulose was not investigated here, but is expected to be comparable to the steam exploded bagasse (Jollez etal. 1992) at comparable severities as used in this work.

AQUEOUS EXTRACTION OF SUGARCANE BAGASSE:

A 20-liter Monel batch digester (Figure 1) was used for the bagasse extraction. In most cases, the digester was charged with 1 kg of whole sugarcane bagasse from a nearby Louisiana sugar mill (Table II) and an amount of water such as to obtain the desired (dry) solid - liquid ratio, where the liquid is the water added and the one in the raw material. The ratios of 1:5 and 1:10 were used, the former is close to the minimum amount of liquid that will still allow a sufficient degree of agitation in this type of reactor. Naturally, reducing the amount of water used for extraction will lead to considerable savings later in recovering the extracted sugars. In some experiments, the raw bagasse was passed once through a Bauer disk mill, giving finer fibrous particles of around 0.2 x 8 mm size, and extracted as before.

After the reactor was charged and closed, steam was released to the jacket of the reactor, and counting of the processing time was started when the temperature inside nearly reached the final temperature. This in most cases took between 15 and 30 minutes. During the extraction the reactor was rotated at about 0.3 rpm. When the desired processing time (and treatment severity) was reached, steam supply was turned off and the liquid discharged through a screen from the bottom of the reactor. Solid residues were recovered after cooling and opening the reactor. The amount of water evaporated during discharging of the (hot) reactor was calculated from the water balance. Processed bagasse sample was washed with deionized water, and in some cases dewatered with a hydraulic press. All samples were kept frozen in closed containers until further analysis.

Raw aqueous extracts were cloudy green-yellowish liquids, darker at higher severities. Dissolved solid contents of the liquid samples was measured by refractometry, their turbidity in NTU with a Hach ratio turbiditimeter, and the moisture contents in the solid samples was determined by drying at 95 C for 150 minutes with an infrared moisture analyzer. As the extraction of pentosans (xylans) was the main focus of this work, each extract was analysed in detail for its content of free xylose, total pentosans and pentosans water soluble at ambient temperature.

The contents in the extract of the total xylan was obtained from the differences in xylose concentrations determined in the raw extract and extract subjected to complete hydrolysis with 6.5 % w/w H_2SO_4 for 2 hours at 100 C. The contents of the insoluble xylan was determined from xylose concentrations in an extract first clarified by filtration with a 0.45 micron cellulose acetate disk, prior and after complete hydrolysis. The soluble xylan was then obtained as the difference between the two. Since no free xylose is expected to be present in the original bagasse, the xylose content of the raw extracts is assumed to corresponds to the xylan autohydrolyzed during extraction.

The monosaccharides in the raw and hydrolyzed extracts were determined with HPLC, with either an anion exchange CarboPac PA1 column (Dionex) and a PAD detection, or with a cation exchange sugar column (Bio-Rad) and an RI detector.

In addition, carbohydrate and lignin analysis of the solid samples, and in some cases of the extracts as well was done at the Biobased Materials Center and the Department of Wood Science and Forest Products at Virginia Polytechnic Institute, using a slightly modified version of the summative analysis procedure outlined previously (Kaar et al., 1991). Solid samples were milled to a 40 mesh size or less with a Wiley mill, and dried over P_2O_5. 0.1 g (dry weight) samples were taken and placed in 50 mL glass autoclave bombs, combined with 1.0 mL 72 % H_2SO_4 and incubated in a 30 C water bath for one hour with occasional stirring. After incubation, 30 mL distilled deionized water was added to each sample bomb, sealed and autoclaved at 120 C for one hour. After cooling, the acid-insoluble (Klason) lignin was filtered out, and determined by drying at 105 C.

To account for the loss of one water molecule on formation of a glycosidic bond in the polysacacharides, the contents in the original material of the polysaccharides was calculated from the concentrations of the monomers determined with HPLC using a factor of 0.9, the amount of glucan hydrolysed in the analytical extraction to HMF using a factor of 1.3, and the amount of xylan degraded to 2-F using a factor 1.4 (Karr, 1991).

The diluted filtrate was analyzed for its contents of acid soluble lignin by measuring its absorbance at 205 nm. The sugars, glucose, fructose, xylose, galactose, arabinose and mannose and their acid degradation products, hydroxymethylfurfural (HMF) and 2-furfural (2-F), were determined with HPLC equipped with cation exhange columns with RI (sugar) and UV (277 nm, furfurals) detection (Kaar et al; 1991). Thermogravimetric ash was determined at 800 C at 10 C/minute under an air purge.

For comparison's sake, a few tests were done on extraction at conditions identical to those suggested as "optimum" for dilute acid pretreatment (Bernhardt and Proudfoot, 1990):

0.7% H_2SO_4 (concentration calculated including the bagasse moisture), solid (bone dry) : liquid ratio 1:5, at 132 C and 75 minutes.

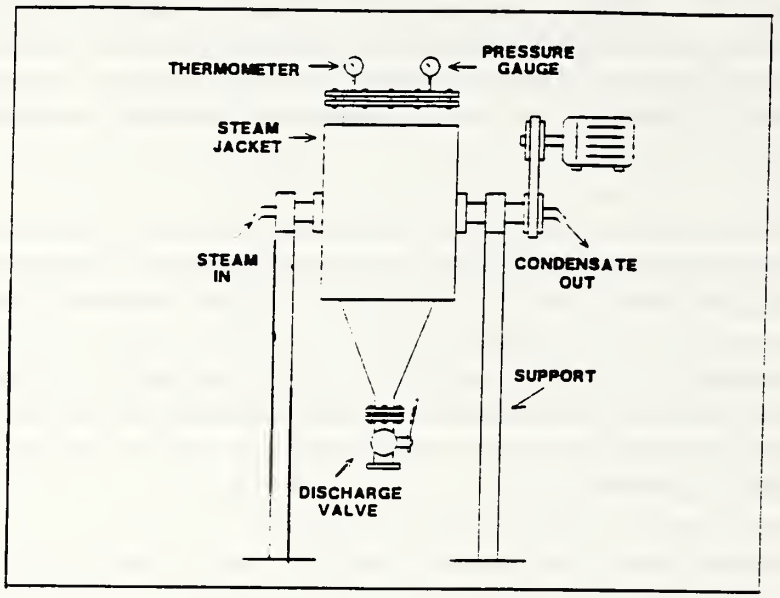

Figure 1: The 20 liter Monel digester used for extraction of sugarcane bagasse. The jacket of the reactor was heated with steam and rotated at circa 0.3 rpm around its axis.

TABLE II: Average composition of the Louisiana sugar cane bagasse used for the aqueous and dilute acid extractions, in weight % dry basis.

GLUCAN	39.1
XYLAN	18.0
GALACTAN	1.4
ARABINAN	2.4
MANNAN	0.5
KLASON LIGNIN	22.6
ACID SOLUBLE LIGNIN	1.9
THERMOGRAVIMETRIC ASH	4.4

RESULTS:

On average, raw bagasse contained 39.1 % glucan, most of course in the form of cellulose, although an amount comparable to that of arabinose (Bernhard and Proudfoot, 1990) may be a part of the hemicellulose complex. The cellulose content found here agrees well with the 38% reported from South Africa (Trickett and Neytzell-de Wilde, 1982) and 36.8 % from Louisiana (Paturau, 1989). The total content of hemicellulose, a xylose-based polysaccharide (Nagaty, 1982; duToit et al; 1984) with some glucose, arabinose, galactose, and mannose and assuming that 2.4 % glucan came from hemicellulose instead of cellulose, and disregarding the minor contribution to hemicellulose from the acetyl, glucuronil and methyl groups that split off on hydrolysis) is 24.7%, somewhat lower than reported for Louisiana bagasse but within the wide range of 20 to 33 tabulated for a number of cane varieties and geographical conditions

(Paturau, 1989). No fructose was detected in any of the samples.

The aqueous extracts (Table III) are dilute turbid products with 2.5 to 3.5 % dry solids, slightly acidic (pH 4 to 4.5) on account of acetic acid released from hemicellulose during hydrolysis, with the sugar purity (% of dry solids) close to 50%. Xylose is the main component, and to a large degree still present as xylose-based oligo and polysaccharides as indicated in more detail in Figure 2. HFH and 2-F determined in the extracts using the summative analysis of Kaar (1991) in the amounts roughly 0.5 % (dry basis) were again assumed to be the artifact of the analysis and were added, using the factors given earlier to glucose and xylose respectively. Although some were certainly generated during extraction, these are likely to be volatilized during discharge of the superheated contents after the cook. Furthermore, their contents found in extracts were comparable to those in the original bagasse, where no HMF and 2-F is expected.

The effects of time and temperature on the extent of solubilization of carbohydrates were combined in a single severity factor R,

$$R = t * EXP((T-100) / 14.75)$$

with residence time t in minutes, and temperature T in degrees C as suggested earlier (Overend and Chornet, 1987; Glasser, 1991). The extraction temperature ranged between 150 and 170 C, (steam pressure between 0.68 to 1.01 MPa or 100 to 150 psig), so that the variations of log R in figure 2 reflect variations in both time and temperature. Although the severity factor equation, based on the assumed equivalence of time and temperature effects appears to hold reasonably well, there is some indication that higher temperature/shorter time conditions give somewhat better yields than lower temperature/longer time combinations. Overall hemicellulose extraction (reported as xylose in Figures 2 a and b) peaked at a severity 3.9 for both ground and "as is" bagasse. For ground bagasse (Figure 2 b), at log R of 3.9, a total of 14 g xylose or 89 % of the original amount was recovered in the extract per 100 g dry bagasse. Of the recovered total, 9 % is in the form of an insoluble xylan, 74% as water soluble xylan and 17% as free xylose. With "as is" bagasse (Figure 2 a), the recovery was about 60%, considerably lower than with finely ground bagasse, with about the same ratios of the soluble xylan, insoluble xylan, and free xylose.

The recovery of the water insoluble fraction was favored at lower severities (3.7), although at these conditions most of the extracted xylan has already been solubilized but not yet completely hydrolyzed. The term water soluble refers here to ambient temperature, and it does not necessarily imply that this fraction was not solubilized at the extraction conditions. In absence of more detailed structural analysis, it is assumed that it refers to that part of xylan that more or less depolymerized during the extraction, rather than to a structurally different oligo or polysaccharide. As the severity of the treatment increased, the yields of insoluble and soluble xylan fractions became lower and nearly zero at log R of 4.3. The sugar degradation is apparently already substantial around the "optimum" severity 3.9, and the sugar yield became

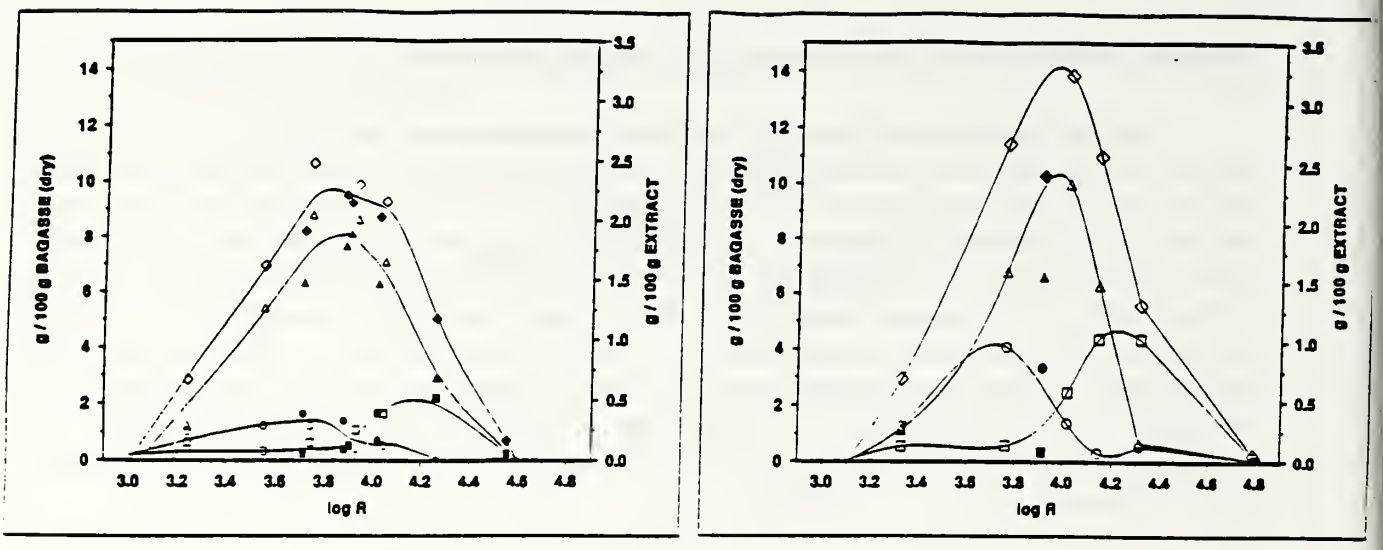

Figure 2: Recovered amounts and extract composition at various severities of aqueous bagasse extracts. (a) "as is" bagasse, (b) ground bagasse. Solid symbols: pressure ca. 100 psig, 155 C, Empty symbols: pressure 130 - 150 psig, 160 - 170 C. ○ insoluble xylan (reported as xylose), △ soluble xylan (as xylose), □ free xylose, ◇ total recovered xylose.

practically zero at log R 4.8. No xylan/xylose extraction is expected below severities of 3.2. No significant difference in sugar yield was found between the extractions with solid:liquid ratios 1:5 and 1:10 respectively.

The residual bagasse (Table IV) still contains a substantial amount of unsolubilized xylan, corresponding perhaps to the fraction of bagasse hemicellulose reported earlier to form between 23 - 39 % of the total that is extractable from bagasse with diluted acids at a distinctly slower rate (duToit, 1984) than the first fraction. Two tests performed here with dilute H_2SO_4 hydrolysis confirmed higher degree of hemicellulose extraction, i.e. lower residual concentration in extracted bagasse at extraction conditions recommended by Bernhard and Proudfoot (1990), but not necessarily higher recovery in the liquor because of faster xylose degradation at higher acidities (Sanchez, 1990).

Table III: Representative extract composition (as monosaccharides) from aqueous and dilute acid extractions of "as is" bagasse. All in % dry solids, except dissolved solids (from RI) that are in g/100 g solution.

COMPOUND	AQUEOUS	DILUTE ACID
pH	3.9	2.0
DISSOLVED SOLIDS	2.8	7.4
XYLOSE	43.4	35.9
GLUCOSE	1.0	9.7
GALACTOSE	2.0	1.0
ARABINOSE	4.2	1.9
MANNOSE	0.0	0.0
KLASON LIGNIN	8.9	-
ACID SOLUBLE LIGNIN	11.8	-
THERMOGRAV. ASH	33.5	-
SULPHUR	0.2	2.7

Table IV: Representative composition of the residual bagasse, after aqueous and acid extractions of "as is" bagasse.

COMPOUND	AQUEOUS	DILUTE ACID
GLUCAN	50.1	53.3
XYLAN	7.6	1.3
GALACTAN	0.3	0.0
ARABINAN	0.0	0.3
MANNAN	0.0	0.0
KLASON LIGNIN	30.7	35.0
ACID SOLUBLE LIGNIN	1.2	1.3
SULPHUR	0.2	1.1

DILUTE ACID HYDROLYSIS OF AQUEOUS EXTRACTS:

At the conditions found optimum here for the solubilization of hemicellulose, 80% of the extracted xylose is still in the oligo- or polysaccharide form, and unless these are the target compounds, post extraction hydrolysis is necessary prior to fermentation or xylose recovery by crystallization or chromatography. Both dilute acid and enzymatic hydrolyses are feasible, although the latter may be complicated by the heterogeneity of the xylans. Dilute H_2SO_4 was chosen here, primarily because of its low cost and a possibility of near complete recovery from the hydrolysed extracts.

In order to reduce the extract volume and reduce the acid consumption, the raw extracts were first concentrated under vacuum to 20 - 40% dry solids. Prelimary experiments showed that the rate of hydrolysis depended only on temperature and acid concentration (mass 98% H2SO4 per unit mass of the concentrated extract), but not on the extract concentration up to about 30 % dry solids. There was some indication though that conversion becomes less at extract concentrations of the order of 40%. Furthermore, since during the hydrolysis, additional fine and bulky acid-insoluble lignin precipitates, the high concentration slurries are difficult to handle. A concentration of 25% dry solids was therefore chosen as a compromise between minimizing the acid use (t H2SO4 / t xylose) and ease of clarification of the hydrolyzed slurries. Near 100% hydrolysis is achieved within 30 to 90 minutes, depending on the acid concentration and temperature (Figure 3), although some care must be taken because of rapid xylose degradation above 100 C. The lignin precipitated in the hydrolysis tends to cake and settle on the walls and bottom of the reactor. Addition of 1 - 1.5% (w/w) of fine extracted bagasse to the reactor at the beginning of the hydrolysis was found sufficient to prevent caking.

Acid consumption (98% H2SO4) in the hydrolysis is between 0.8 (condition 1 in Figure 3) and 0.2 kg (conditions 3) per 1 kg xylose produced, or $0.064 to $0.016. The lignin in the hot hydrolyzed extracts is in the form of fine suspension, in part probably bound to the fine bagasse particles added to the reactor to prevent caking. More lignin precipitates as the solution cools. Any physical clarification (filtration or centrifugation) must therefore be done at low temperature. Preliminary laboratory trials with pressure filtration at room temperature gave very low fluxes, of the order of 30 - 100 l/m2/hr, and because of cake compressibility, nearly independent of the pressure in the range 20 to 60 psi. Centrifugation after cooling to ambient

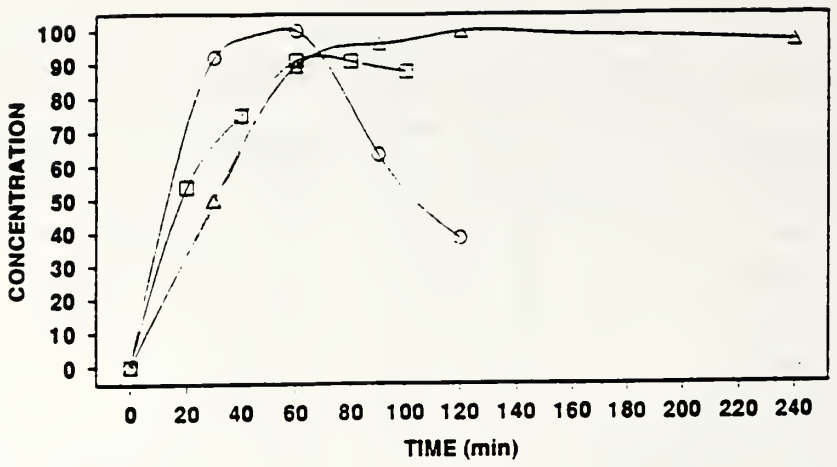

Figure 3: Relative xylose concentration in solution at 3 hydrolysis conditions : ▵ 100 C (atmospheric pressure), 7.0 g of H2SO4 (conc.)/ 100 g concentrated aqueous extract. □ 100 C, 4.2 g H2SO4/100 g. ○ 130 C, 1.5 g H2SO4/100 g. 26 % DS concentrated extract.

temperature with laboratory batch and continuous solid bowl centrifuges at 2000 - 3000 g gave clear solutions with turbidities between 50 - 250 NTU (at 25 % dry solids). The extracts (Table V) clarified in this way are stable (no turbidity develops) and suited for xylose recovery.

Increase in glucose content compared to the raw extracts (Table III) prior to hydrolysis is probably from cellulose hydrolysis of fine bagasse particles that passed through the screen and the 1% ground pretreated bagasse added to the hydrolysis reactor to prevent caking of the lignin precipitate. Sixty to 70% of the lignin in the raw extract is removed in the clarification, and recovered as a solid cake in a 3:1 mixture with fine bagasse, at a rate of 0.05 kg lignin (dry) per one kg bagasse (dry) extracted.

TABLE V: Representative composition of the clarified hydrolysate, excluding sulphuric acid, in g per 100 grams non-H2SO4 solids.

COMPOUND	g/100 g
GLUCOSE	5.6
XYLOSE	45.9
GALACTOSE	1.8
ARABINOSE	4.0
MANNOSE	0.0
KLASON LIGNIN	1.8
ACID SOLUBLE LIGNIN	7.4

RECOVERY OF H_2SO_4 FROM HYDROLYZED EXTRACTS:

A simulated moving bed (SMB) adsorber with 8 columns packed with Dowex Monosphere 99 chromatographic resin (320 micron particle size) in H+ form was used to partially optimize the H2SO4 - sugar separation. More detail on the installation, procedures and fundamentals of the SMB operation can be found in our previous publications (Saska et al; 1992) and general literature on industrial chromatography separations (Wankat, 1986). All columns in an SMB system such as the one in Figure 4 are connected in series. Periodically, all the inlet (water, feed, and internal recycle) and outlet (sugar and acid products) are displaced in the direction of the liquidflow. This simulates motion of the resin against the direction of liquid flow and achieves advantages of a counter-current operation.

Preliminary experiments with batch separation on single one meter columns, packed with the identical resin as the SMB system, indicated no separation (identical chromatographic behaviour) between glucose and xylose on the H+ form of the resin. 10 SMB tests, each lasting between 10 and 20 hours were done, 2 with hydrolyzed extracts, the rest with synthetic sulphuric acid - glucose mixtures, with xylose added in smaller quantities in some tests to further verify that the two sugars behaved identically. The feed for the SMB trials consisted characteristically of 4% H_2SO_4 and 16 % sugar, corresponding roughly to an extract hydrolysed with 4 kg H_2SO_4 per 100 kg of the 25 % dry solids extract.

The operational parameters and performance are summarized in tables VI and VII. The sugar product is only slightly diluted with 15% dry solids, of nearly 100% purity (almost no acid present), containing 94% of the sugar present in the feed. The remaining 4% go into the acid product, which is more dilute with 2% dry solids, 95% acid recovery and 95% acid purity.

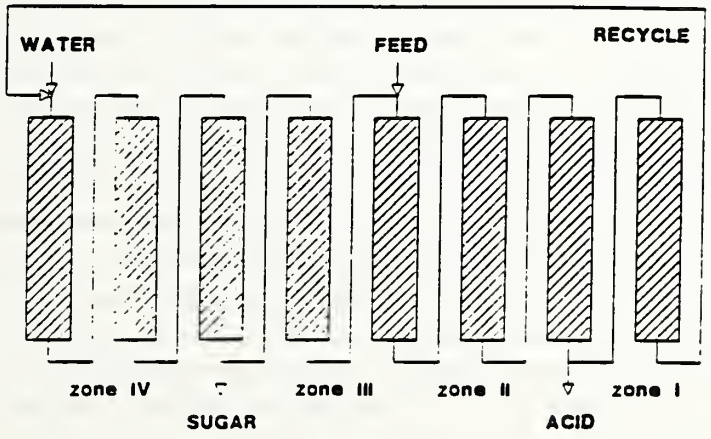

Figure 4: Schematics of the 8-column, pilot-simulated moving bed (SMB) adsorber. The flow direction in all in-series connected columns is downward, the arrows indicate the inlet (water, internal recycle and feed) and outlet (sugar product and acid product) ports. The periodic switching of all ports downstream simulates the counter-current motion of the resin.

Table VI: Parameters of the acid - sugar SMB separation.

FEED, ml/min	90
WATER, ml/min	234
ACID PRODUCT, ml/min	229
SUGAR PRODUCT, ml/min	90
RECYCLE, ml/min	214
SWITCH TIME, min	8.4

Table VII: Purity and recovery of SMB products.

SUGAR		ACID	
RECOVERY	PURITY	RECOVERY	PURITY
94 %	100 %	95 %	95 %

The acid product was concentrated under vacuum, and reused for hydrolysis of the crude extracts. The hydrolysis rate was found identical as in the case of hydrolysis with fresh H_2SO_4.

DISCUSSION:

Principal elements of a process for steam-pretreating of sugarcane bagasse in preparation for acid or enzymatic hydrolysis of cellulose, and production of a xylose-rich syrup for xylose, arabinose or galactose production is presented in Figure 5. Bagasse is pretreated, preferably in a screw-fed continuous digester (1) of the PANDIA type advocated for rapid pulping of non-wood plant fibrous materials (Atchison, 1992). The dilute aqueous extract is concentrated to 25 - 30% DS in the evaporator 2, and fully hydrolyzed with sulphuric acid in the reactor 3. Preferably, a small amount (1% of the weight of the concentrated extract) of ground raw or pretreated bagasse is added in the hydrolysis reacot to prevent caking of the acid-insoluble lignin precipitate. After cooling the hydrolysate-lignin suspension, it is clarified with a continuous decanting centrifuge 5. The clear delignified hydrolysate is further concentrated in the evaporator 2, and into the eight column continuous ion-exclusion separator where at least 95% of sulphuric acid is recovered and recirculated back into the hydrolysis reactor 3. Approximately 15 % DS syrup composed of xylose, smaller quantities of glucose, arabinose and galactose and other non-sugar impurities can then be fermented or purified and further separated into its individual sugar components with either a batch or preferably a continuous chromatography system analogous to the one used here for recovery of sulphuric acid. A simultaneous separation of three components, e.g. xylose, glucose and arabinose is feasible (Anon., 1993; Saska, 1993) with a modified simulated moving bed system.

Some aspects of the proposed process remain to be verified on a realistic pilot facility: the efficiency of hemicellulose extraction with a continuous system, at same severity but with less water then used in the present batch system, the enzymatic digestibility of the pretreated bagasse, purification and fractionation of the xylose syrups and combustion or other properties of the lignin fraction. On the other hand, the hydrolysis of the concentrated extracts, clarification

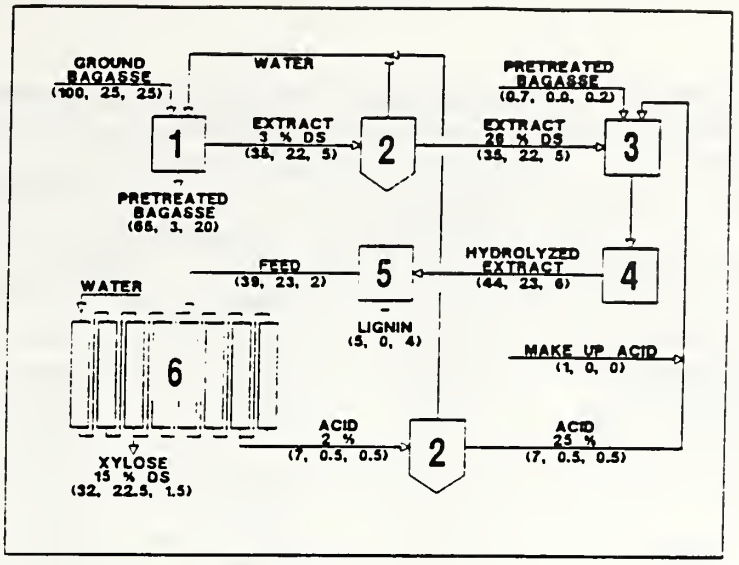

Figure 5: Schematics of a process for steam/aqueous pretreatment of ground sugarcane bagasse and production of 15% DS xylose-rich syrup, with continuous ion-exclusion recovery of sulphuric acid. 1 = hemicellulose extraction, 2 = multistage vacuum evaporation, 3 = xylan hydrolysis, 4 = cooling, 5 = centrifugal clarification, 6 = continuous ion exclusion. The numbers (X, Y, Z) in parentheses indicate the approximate mass flows of the principal components: X total solids, Y hemicellulose components, Z lignin.

of the hydrolysates, and the recovery of sulphuric acid from the sugar-acid mixtures can probably be scaled up quite confidently based on the present results.

For a cost estimate, two scenarios were considered (Table VIII): (1) 15 % DS xylose-rich syrup is produced and all pretreated bagasse is returned to the boilers, and (2) pretreated bagasse is further hydrolyzed with 90% efficiency to glucose syrup. 60 and 90% hemicellulose extraction efficiency was considered as a basis for "as is" and ground bagasse. No by-product credit was given for the lignin product. With the bagasse composition as in Table II, the sugar (monosaccharide) yields used for the calculations, in kg sugar produced/kg (dry) bagasse, were in case of xylose syrup production only: 0.168 and 0.253 for "as is" and ground bagasse respectively, and in the case of production of both xylose and glucose syrups, the latter by cellulose hydrolysis, 0.494 and 0.620 respectively. For a conservative estimate, the raw material cost was included at $0.03/kg (dry), although the true cost of the first 10 % or so diverted from the boilers is expected to be close to zero, if the bagasse hydrolysis facility is operated at the mill site and jointly with the conventional sugarcane milling process. With the by-products credit, the raw material cost adds $0.026/kg sugar, without this cost, the estimates range from $0.039 to $0.118 /kg sugar. The former, assuming hydrolysis of both hemicellulose and cellulose, excludes the actual cost of cellulose hydrolysis. For the concentrated H2SO4 process, Hartfield (1993) estimated the resin and evaporation cost at $0.04/kg sugar. This may be a conservative estimate considering that the actual water and resin use in the acid recovery process that were established in the present work are lower than anticipated by Hartfield (1993) based on single column experiments.

Table VIII: Estimated pretreatment costs, for production of 15 % DS syrup of xylose (with minor amounts of glucose, arabinose and galactose) including energy and chemical cost and by-products credit, in $/kg sugar produced.

	GROUND BAGASSE		MILL RUN BAGASSE	
	(1)	(2)	(1)	(2)
RAW MATERIAL	0.119	0.048	0.179	0.061
BAGASSE PREPARATION[1]	0.020	0.008	0	0
HEMICELLULOSE EXTRACTION[2]	0.040	0.016	0.060	0.020
EVAPORATION (EXTRACT AND DILUTE H2SO4)[3]	0.022	0.009	0.034	0.011
HYDROLYSIS[4]	0.001	0.000	0.002	0.001
CLARIFICATION[5]	0.003	0.001	0.004	0.001
ACID RECOVERY[6]	0.012	0.005	0.018	0.006
BY-PRODUCTS CREDIT[7]	-0.093	-0.022	-0.153	-0.034
TOTAL	0.124	0.065	0.144	0.066

[1] 0.10 kWh/kg bagasse (dry) (Purchase etal, 1986); $0.05/kWh
[2] 3.8 kg steam/kg bagasse (dry); steam $0.0045/kg
[3] 6.3 kg water/kg bagasse (dry), 1.3 kg steam/kg bagasse (dry)
[4] 0.00075 kg H_2SO_4/kg conc. extract, H_2SO_4 at $0.08/kg
[5] 0.0025 kWh/kg conc. extract
[6] electricity and resin replacement
[7] at same moisture content, same value as original bagasse

In comparison with dilute acid extraction of hemicellulose, the aqueous process presents several advantages: lower corrosion conditions in extraction and extract concentration, less xylose degradation in extraction, less degradation by-products in the extracts and pretreated bagasse. In case that the pretreated bagasse is sent back to the boilers for steam generaiton, absence of added sulphur in case of steam/aqueous pretreatment will be of importance. Although the acid use is about the same in both processes, acid is easily recoverable from hydrolyzed concentrated and clarified extracts. With particle size reduction prior to extraction, aqueous process gives almost 90 % recovery of xylose, superior to dilute acid (Bernhard and Proudfoot, 1990) or steam explosion based extraction (Jollez et al; 1992). In addition, the aqueous extraction at moderate temperatures around 170 C as employed here offers the possibility of isolation of xylan oligomers for alternate uses (Rauschenberg et al, 1990; Stscherbina and Philipp, 1991).

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SUGARCANE RIND PROCESSING FOR TEXTILES AND GEOTEXTILES

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Introduction:

A process under development for extraction of fiber bundles from the rind of sugarcane is being pursued and adapted to kenaf also [1-5]. In this process bundles of cellulosic fibers are extracted from the rind of either sugarcane or kenaf and converted to geotextile mats or spun into textile yarns. Instead of converting the rind to ultimate fiber cells as is done in wood pulping, the fibers are retained in bundles with sufficient length for these applications and the cross-section reduced in a controlled fashion.

Process:

There are four distinct steps used in this process: mechanical separation, chemical extraction, steam explosion, and product formation [2,4]. Initial process development was funded by a grant from the Louisiana Education Quality Support Fund (LEQSF). In the first step the rind is prepared using the Tilby process to mechanically separate the pith from the rind by splitting and routing actions [1]. The Tilby was developed for sugarcane processing to mechanical separate the sucrose containing pith cleanly from the cellulosic rind. Since nearly complete separation is achieved, use of this mechanism reduces to one the number of dissolution and precipitation steps necessary to obtain a table ready brown sugar as opposed to the multiple steps characteristic of the crushing and extraction processing [4].

The second step consists of extracting controlled length fiber bundles from rind strips using low concentration alkaline solutions. The key to this extraction step is removing controlled amounts of lignin and hemicellulose, while subjecting the material to specific mechanical action [1-5]. This step differs significantly from pulping actions since the intent is to essentially retain the length of the fiber bundles while reducing the cross section. Therefore, only low concentration NaOH (0.1 to 1.0 N) is used and no sulfates are employed [4]. The sulfates would be the cause of environmental problems; whereas, at a sugar mill the slightly alkaline discharge is welcomed since the normal effluent from the mill is acidic. The mechanical action can be either an oscillatory agitation, or a tumbling motion, and assists with preferential reduction of the cross section rather than the length [4]. Both sugarcane and kenaf tend to split parallel to the long axis of the stalk since this is the direction in which the cellulosic fibers are aligned. By coupling the chemical treatment and the specific mechanical action the new surfaces created by splitting are more accessible than the regions between the ends of fiber cells, thereby favoring the lignin and hemicellulose removal from the split surfaces. Apparently this splitting and enhanced chemical reaction continues throughout this chemical extraction step. The extracts are also being studied by colleagues for use as valuable chemicals.

In the third step the fiber bundles are reduced in cross section further by steam explosion discharge. This step can be bypassed and somewhat similar fiber bundles produced using a more severe treatment in the extraction step. Relatively low steam pressures (0.8 to 1.0 MPa, i.e. 120

to 145 psi) are used both for manufacturing convenience and to be above the melting point and below the degradation temperature of lignin [4]. Saturated steam at 0.8 and 1.0 MPa corresponds to temperatures of 170 and 182 C respectively, and melting of lignin starts at 125 C with degradation onsetting at 195 C [6]. The crushing operation of a sugar mill is normally powered by 3 MPa steam with the exhaust steam being around 1 MPa or slightly lower. The exhaust steam is used for the evaporators but the steam requirement is dictated by the crushing operation.

The fourth step in this process is specific to the potential application. If that application is non woven mats then a slurry of the fiber bundles is deposited on a screen, dewatered and dried [4]. For yarn applications the wet fiber bundles are dried in a fluidized bed and pneumatically conveyed to a bag house for collection. These dried and relatively separated bundles then are treated in a similar fashion to other fibers to be spun into yarns [5].

Sugarcane and kenaf are similar in the aspects critical to utilization of this process. Both are relatively straight grassy stalks with distinct differences between the pithy central region and the more rigid rind. The rind in both contains cellulosic fibers and significant levels of lignin as the primary adhesive holding these fibers into a rigid form. These cellulosic fibers in both plants have a high degree of alignment with the length direction of the stalk and therefore cause the stalk to have a preference to split parallel to the fiber axis direction. The pithy core of each has much less structural integrity than the rind. After the stalk is split in half, the pith can be routed out and cleanly separated from the flatten stalk. This pith in sugarcane is the source of essentially all of the sucrose for which the sugarcane is harvested. However, other uses of the pith are developing for kenaf.

Applications:

Geotextile biodegradable mats are the potential application that has received the most interest to date for the fiber bundles produced in this process. Research on this application for sugarcane is being funded by the Louisiana Transportation Research Center (LTRC). These geotextile mats have potential particularly for use in soil erosion control and can be formed by either direct discharge from the delignification reactors or by steam explosion and subsequent deposition on flat surfaces. Since the process is in essence a wet chemical retting action and the routing process is effective, the resultant fiber bundles and mats are essentially pith free. Competitive mats now being required by EPA for road construction projects, are all more expensive than the projected cost of producing mats using this process.

Sugarcane rind fiber bundles have been blended with cotton, spun into yarns and knitted into a fabric sample. This was accomplished with the assistance of personnel and equipment at the USDA Southern Regional Research Center (SRRC) in New Orleans. It should be possible to accomplish the same result using kenaf prepared in this process.

Status:

Multiple runs on the 20-liter reactor were necessary to provide sufficient material at nominally the same operating conditions for the needed characterization at this stage of development. A single run for each set of conditions is desirable to have a consistent product

since uncontrolled variables or slight process changes can occur between multiple runs. Therefore, one of the objectives in process development was the design and construction of a 200 liter, stainless steel, jacketed, autoclave reactor. This has been accomplished using a grant from the American Sugarcane League (ASCL) and in-kind services from Cameco Industries in construction and Cinclare Sugar Mill in installation and operation. Cameco constructed the 200 liter reactor rated to 3 MPa for less than the cost of material used. It was installed at the Cinclare operating sugar mill in Brusly, LA during the latter part of the 1993 harvest season.

Future Efforts:

ASCL has provided a second grant for the construction of a pilot scale, continuous reactor and steam explosion system. After building this reactor and utilizing it during the 1994 season, the design parameters necessary to build a larger scale continuous reactor and downstream equipment should be determined. During the summer of 1994, as part of the LTRC grant, a pilot study of plant propagation through non-woven mats formed from sugarcane rind will be conducted. LTRC is currently considered a possible project for 1994-95, in which an erosion control, field study of the effectiveness of the non-woven sugarcane fiber bundle mats, and competitive materials would be conducted on a selected hillside. The next step in the development of this product would probably be submission of a proposal to the USDA Alternate Agricultural Research and Commercialization (AARC) program. This proposal should probably be submitted during the field study to provide optimum development of the process and product. The USDA AARC is a program that has as one of its objective "Conduct product and co-product research, development, and commercialization activities to enhance marketability and economic viability of industrial products from agricultural materials." USDA funding may be available for perhaps half of the development and commercialization cost with the expectation that these USDA AARC funds be repaid when the process and product become profitable. Such a proposal for this sugarcane fiber project should be a joint effort of a private industry and LSU. A patent application (2) is currently pending on the process and products with Drs. John and Billie Collier being the inventors and LSU the applicant. Interested parties should contract Dr. John Collier at 504-388-3038.

Conclusions:

Previous work with sugarcane rind fibers has demonstrated a dependence of fiber bundle and mat characteristics upon delignification reaction conditions and optional steam explosion. Initial work with kenaf demonstrated similar reaction conditions to that of sugarcane rind and therefore a similar dependence should exist. Reaction conditions being studied are rind type and source, sodium hydroxide concentration, reaction time, and steam explosion conditions.

Acknowledgments:

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DESIGN AND MANAGEMENT OF WASH WATER TREATMENT SYSTEMS

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INTRODUCTION:

The project is proceeding on schedule. A report on anaerobic treatment of sugar mill wastewater is being prepared. A manuscript on nitrogen compound transformations and phosphorous compound changes that take place in a wetland treatment system is nearing completion. A model has been developed to describe the biological treatment process in an aerated wash pond. Sampling was conducted for two wash pond systems and one wetland system in this grinding season. The collected data and the data from the research work in previous years will be used to study the best available technology for soil removal from wash water and to calibrate a descriptive BOD decay and DO sag model which has been developed for the wetland system.

RECENT PROGRESS:

1. Development of models to predict the biological process in aerated pond.
About 4,000 measurements of BOD_5, COD, DO, pH, Temperature, alkalinity, TSS and TVSS have been collected from three aerated wash ponds in three sugar mills in last three grinding seasons. A model applied to predict the water quality in an aerated pond during grinding season and a model to predict the water quality improvement process before water discharge have been developed. The data collected in this season can be used to calibrate the models. The models include the organic loading related to cane washed at wash table, the flowrate, the solids loading, pond volume, detention time and the number of aerators. It is anticipated the models could be applied for aerated pond design and management.

2. Development of a model to monitor the water quality in an impounded wetland.
About 300 measurements of BOD and DO have been collected during two grinding seasons from an impounded wetland to treat wash water. A model to simulate BOD decay process and DO depletion and recovery process has been developed. The model will be calibrated by the data collected in this season. This model could be applied to predict the wash water holding period before BOD values meet LADEQ discharge standards, and to offer useful information for the consideration on water reaeration alternatives before discharge.

3. Development of design parameters for solids removal from the wash water
About 3,000 measurements of Total Suspended Solids (TSS), Total Volatile Suspended Solids (TVSS), Total Dissolved Solids (TDS) and pH have been collected from three settling ponds of wash pond systems in three sugar mills in the last three grinding seasons. These settling ponds are operated with different sludge removal practices, with or without lime addition, and are followed by aerated ponds having different sizes.

In order to evaluate the performances of these settling ponds and to derive applicable settling pond design parameters, the collected data were analyzed as follows:

TSS at inlet (mg/L): The average Total Suspended Solids at the inlet of the settling pond during the grinding season. The TSS is contained in the wash water from the cane washing. TSS is supposed to be removed from the wash water in the settling pond.

Removal rate of TSS (%): The removal rate of TSS when the wash water moves from the inlet to the outlet of the settling pond, which is an important parameter to evaluate the pond performance.

TVSS at outlet (mg/L): The average Total Volatile Suspended Solids at the outlet of the settling pond during the grinding season. The TVSS values indicate the organic contents of suspended solids.

Removal rate of TVSS (%): The removal rate of organic parts of the suspended solids in the settling pond.

Volume of settling pond V (cu.ft.): The water volume of the settling pond at the beginning of the grinding season. Because of the solids accumulation in the settling pond the water volume could be reduced during the grinding season.

Surface area of settling pond A (sq.ft.): The surface area of the settling pond.

Wash water flowrate Q (GPM): The wash water flowrate of the settling pond from wash table.

Velocity of wash water flow v (ft/hour): The average wash water flow velocity at a cross section of the settling pond which is derived from Q/cross area.

Detention time θ (day): The hydraulic detention time of wash water in the settling pond which is valued as V/Q.

SS mass flux MF (kg/sec): The quantity of suspended solids that passes into the settling pond per unit time. It is the product of flowrate Q and TSS carried by the inflow.

Daily suspended solids mass loading ML (lb/ft^3day): The suspended solids loading per unit volume of settling pond per day. This parameter can be used to indicate the treatment capacity of the settling pond.

Surface loading SL or Overflow rate (L/m^2day): The hydraulic loading per unit surface area per unit time which is a parameter indicating the critical vertical settling velocity of a discrete particle which can be removed from the pond if its settling velocity is equal to or greater than the SL value.

SS production P (lb/ton of cane): The suspended solids brought into wash water per ton of cane washed at the wash table.

The preliminary results from the data analysis are shown in Table 1.

Table 1. The operational features, characteristics and parameters of three settling ponds.

OPERATIONAL FEATURES			
	Cane Washed (tons/day)	Lime Addition	Mud and Sludge Removal During Season
POND-I-A	5100	No	No
POND-I-B	5300	No	No
POND-II-A	7331	Yes	No
POND-II-B	7812	Yes	No
POND-III-A	9011	Yes	Yes

CHARACTERISTICS					
	V (ft^3)	Q (GPM)	v (ft/hr)	θ (day)	A (ft^2)
POND-I-A	1.584×10^6	12,000	77.82	0.686	132,000
POND-I-B	1.584×10^6	12,000	77.82	0.686	132,000
POND-II-A	0.720×10^6	10,000	145.24	0.374	86,400
POND-II-B	0.720×10^6	10,000	145.24	0.374	86,400
POND-III-A	1.675×10^6	22,500	260.73	0.387	115,920

SOLIDS LOADING					
	Loading (lb/day)	ML (lb/ft^3day)	P (lb/ton)	SL (L/m^2day)	MF (kg/s)
POND-I-A	186,277	1.884	36.52	5,334	1.499
POND-I-B	176,839	1.788	33.37	5,334	1.437
POND-II-A	95,628	2.128	13.04	4,445	0.937
POND-II-B	98,343	2.188	12.59	4,445	0.600
POND-III-A	824,425	7.431	91.49	11,388	5.250

	WATER QUALITY PARAMETER					
	TSS_{in} (mg/L)	TSS_{out} (mg/L)	Removal %	$TVSS_{in}$ (mg/L)	$TVSS_{out}$ (mg/L)	Removal %
POND-I-A	1979.1	687.9	65.3	1568.2	430.5	46.1
POND-I-B	1897.8	671.5	64.6	331.0	212.6	29.7
POND-II-A	1485.4	689.6	53.6	389.0	240.4	37.3
POND-II-B	951.8	133.4	86.0	160.0	56.0	65.0
POND-III-A	3701.0	827.2	77.6	632.4	233.8	58.3

FURTHER WORK:

(1). To make conclusions on the performances of the settling ponds based on the data analysis;
(2). To make suggestions for design parameters for the settling pond; and
(3). To derive a preliminary design procedure for the settling pond.

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